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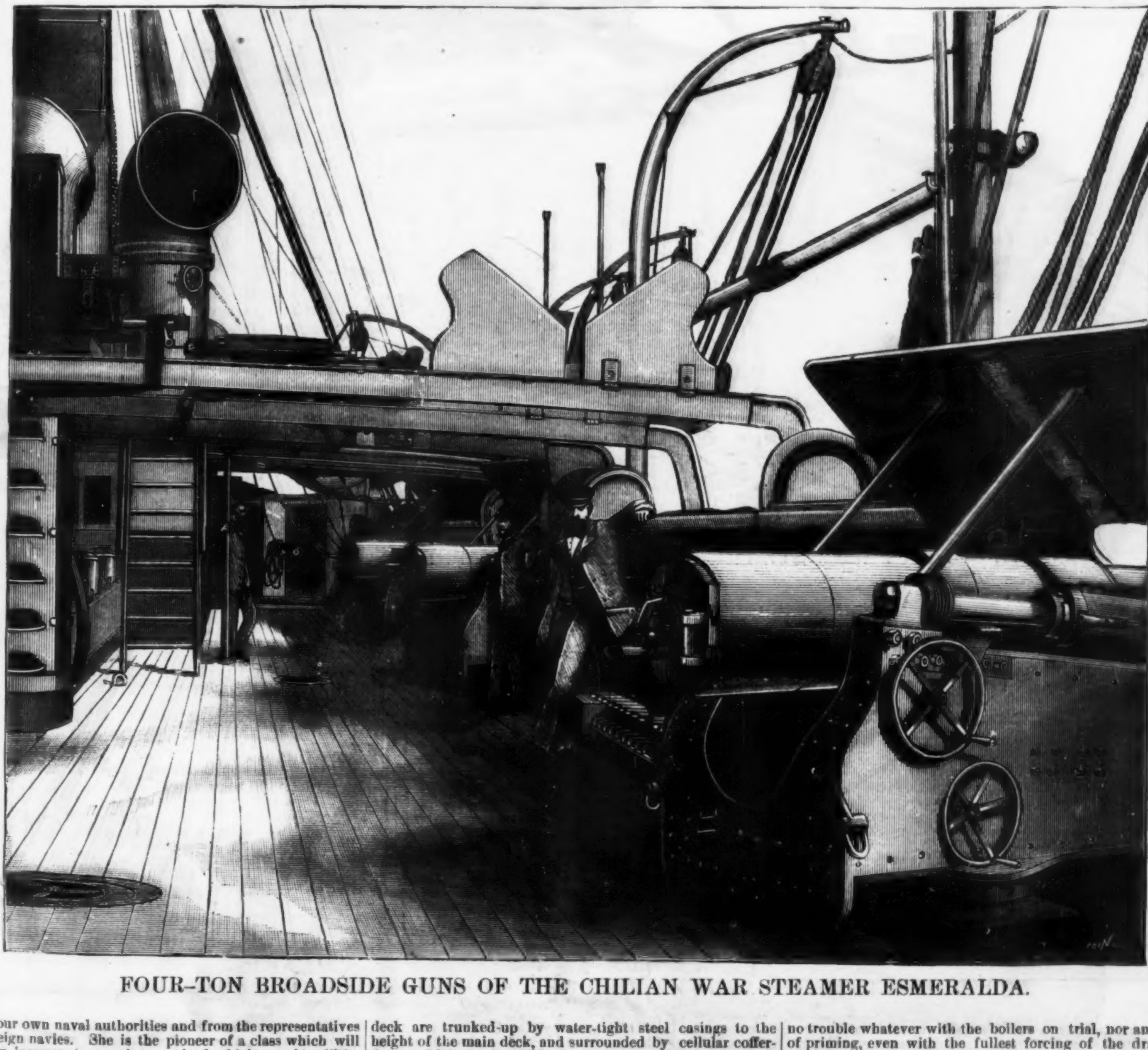
THE CHILIAN WAR STEAMER ESMERALDA.

THIS vessel constitutes a very important addition to a navy which is already the most powerful on the Pacific coast of the American continent. She has been designed, constructed, armed, and equipped for sea on the Tyne by Sir W. G. Armstrong, Mitchell & Co., being the largest war ship yet completed by that firm, which has long made a *specialité* of swift, heavily armed cruisers, and is now undertaking at their new Elswick yard the construction of all classes of men-of-war, armored, protected, or unarmored. Being the first example afloat of the protected-cruiser class, the Esmeralda has naturally attracted great attention, both



FOUR-TON BROADSIDE GUNS OF THE CHILIAN WAR STEAMER ESMERALDA.

from our own naval authorities and from the representatives of foreign navies. She is the pioneer of a class which will rapidly increase in numbers, and of which much will be heard in future naval wars. In addition, she embodies many novelties in structure, propelling apparatus, guns, and gun-mountings, and her trials have been watched closely in consequence. These trials have been completely successful, and much has been learned from them that must be influential on future construction.

We give several illustrations from photographs. The first affords a view of the broadside armament of 6-inch guns, and the third illustrates the mounting of the 25-ton chase guns. To these illustrations a brief description of the salient features of the vessel may be added. She is of moderate size, as modern war ships go. Her length is 270 feet; breadth, 42 feet; draught of water, fully laden, about 18½ feet; and displacement less than 3,000 tons. Her hull is steel-built; she is framed on the ordinary transverse system, and is not wood-sheathed or coppered. There are three complete decks. The upper or gun deck is about 11 feet above water, and upon it all the heavy guns are carried in the open. The main deck is about 5 feet above water, and it is occupied throughout by most excellent quarters and cabins for officers and crew, for whom good natural ventilation and light are secured. The lower or protective deck is of 1-inch steel, and extends from stem to stern; it is strongly arched in the athwartship direction, having a curve of about 4 feet. At the middle line this deck is about 1 foot below water; at the sides it is about 5 feet below. It forms a roof or shelter to the hold space situated below it, and in the space thus protected are placed the vitals of the ship—magazines, shell-rooms, engines, boilers, etc. Minute water-tight subdivision of the hold space below the protective deck, and of the space between it and the main deck, is effected by means of transverse and longitudinal bulkheads and of horizontal flats or platforms. Magazines, shell-rooms, etc., are also converted into separate water-tight compartments. All openings in the protective deck are trunked-up by water-tight steel casings to the height of the main deck, and surrounded by cellular coffer-dams, which can be packed with canvas, oakum, or other material which would readily check the inflow of water if, in action, the trunk casings were shot through. This coffer-dam protection resembles that long used by the Admiralty constructors in vessels of the central citadel type; and another feature in the Esmeralda in which Admiralty practice has been imitated is in the use of cork, packed in cellular spaces, as a safeguard to her buoyancy, stability, and trim in case the sides in the water-line region should be riddled in action. The steel deck is intended to be chiefly useful in protecting from shell fire the vital parts situated below it, and this protection is greatly increased by the conversion of the spaces between the main and lower decks into coal-bunkers. Six hundred tons of coal can be stowed in the ship, 400 tons being the quantity carried on the 18½ foot draught; with 600 tons of coal the draught would be about 19 feet 3 inches. Besides the principal bunkers above the protective deck, there are large bunkers below it and adjacent to the stoke-holes. All necessary facilities are provided for trimming the coal to the stoke-holes, and the bunkers can be readily filled through coal chutes in the sides.

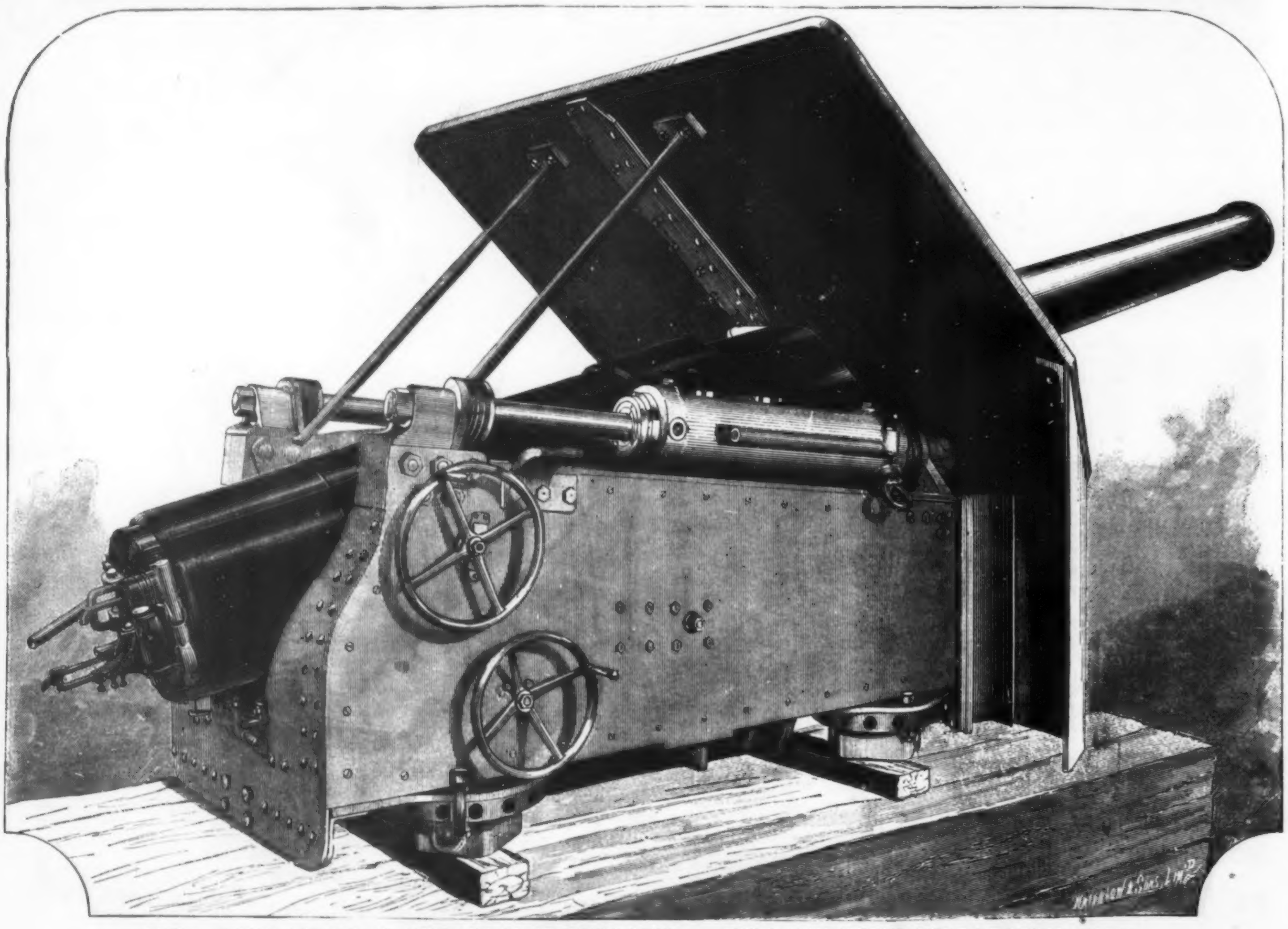
Steam is supplied by four double-ended steel boilers, 13 feet in diameter, and 18½ feet long, each boiler having six furnaces. The working pressure is 90 pounds. There are two funnels and four stoke-holes, the boilers being placed with their length fore and aft, and the stoke-holes being athwartship. Forced draught appliances are fitted to each boiler room, powerful fans being used to draw down large quantities of air and to put the stoke-holes under pressure when the higher speeds are being attained. It was an interesting experiment to work boilers of this type under forced draught conditions, and the results were found to be entirely satisfactory. Ample steam-producing power has been secured, and with only about 1¼ inch to 1½ inch of water in the pressure gauges, the boilers gave a supply of steam more than sufficient to meet all requirements. There was no trouble whatever with the boilers on trial, nor any sign of priming, even with the fullest forcing of the draught. Had it been desired, a considerably greater quantity of steam could have been obtained by running the fans quicker, and increasing the air pressure, but there was no necessity for this course, and the moderate air pressure which proved sufficient might have been continued over a long period without difficulty.

She has twin screw propellers driven by two independent sets of machinery. The engines are horizontal, and on the two-cylinder compound principle. The cylinders are 41 inches and 82 inches in diameter, and the stroke is 36 inches. Messrs. R. & W. Hawthorn, of Newcastle, are the engineers who designed and built the engines and boilers, and they are to be congratulated on the great success achieved. Mr. Marshall, of that firm, has, as is well known, taken the greatest interest in the development of the forced draught system, and in the Esmeralda better results have been attained than in any previous vessel of large power. The engines were run very fast on the trials—120 to 130 revolutions per minute—and all went well. The acceptance of this high piston-speed, the use of forced draught, and the free use of steel, have enabled great engine power to be obtained with comparatively little weight. This is the more creditable as the existence of the protective deck necessarily

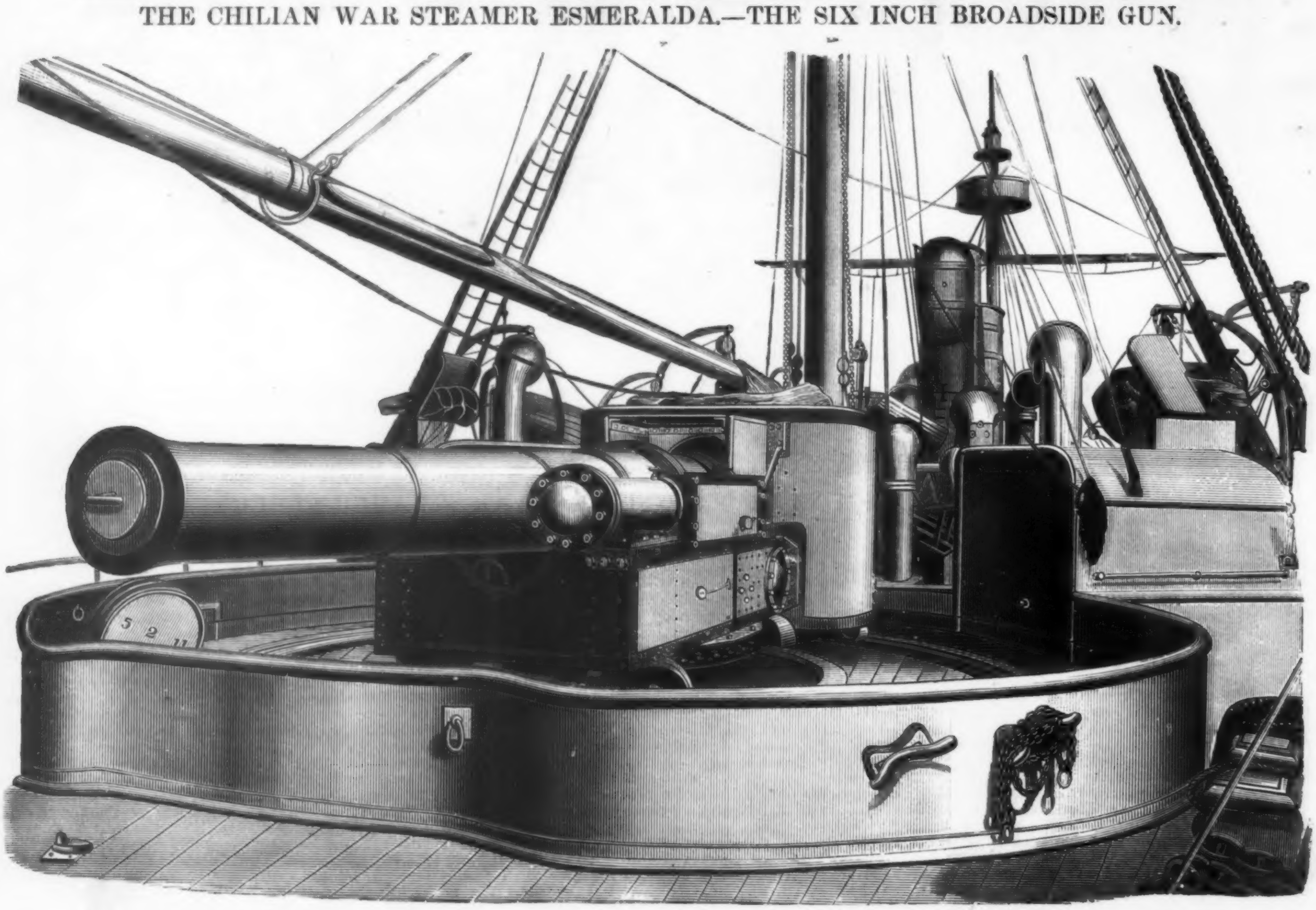
cramped the spaces into which engines and boilers had to be fitted. At the Tynemouth Exhibition of 1882 there were exhibited the after-pieces of steel shafting for the Esmeralda, and those who saw them well remember their great length and excellent quality This length was unusually great on account of two reasons: first, the very fine form of the vessel; and secondly, the exceptionally large distance of the screws abaft the body of the ship. It was decided, therefore, to fit two supporting struts on each side; and in this respect the Esmeralda resembles the Iris and Mercury, although the arrangement of her shafting is not similar.

The speed trials took place about the middle of July last, off the coast at the mouth of the Tyne. They were made with the ship fully laden, weights being placed on board to represent the powder, provisions, etc., not in place when the trials were made. A distinguished party were on board, including three members of the Board of Admiralty, and Captain Lynch, of the Chilian Navy, who has acted as chief of the commission to whom has been intrusted the onerous duty of arranging for the construction of the vessel, and inspecting the work throughout all its stages. The mean speed declared as the result of the trials was 18¼ knots per hour. The Iris, fully laden for sea, made 18 knots per hour, and at her light trials made 18·6 knots. The total horse-power indicated on the trial approached 6,500 horse-power; and about 6,000 horse-power was indicated by the main engines, the balance being due to the auxiliary engines. From these figures it will be seen that the performance of the Esmeralda is exceedingly good, taking into account her moderate size in relation to her high speed.

Besides the full-speed trials, the builders made a most exhaustive series of progressive trials at various speeds, thus extending their information of the capabilities of the vessel,



THE CHILIAN WAR STEAMER ESMERALDA.—THE SIX INCH BROADSIDE GUN.



TWENTY-FIVE-TON STERN CHASER OF THE CHILIAN STEAMER ESMERALDA.

and her rate of coal consumption at working speeds such as she will ordinarily run at. It has thus been proved that, starting with 600 tons of coal on board, the Esmeralda can traverse about 6,000 knots at a speed of ten knots per hour, or about 8 000 knots at a speed of eight knots per hour. Further, it has been ascertained that with one set of engines only at work, and with one screw, the ship can be kept on a course with a very small angle of helm, and can thus be worked most economically. At all speeds she steers exceedingly well, whether the hand gear or the hydraulic gear is used. Her moderate length and good rudder-power make her a very handy ship, and she has a powerful ram bow. With the hydraulic gear the helm can be put hard over in from twelve to fifteen seconds, when the vessel is at full speed. Careful observation showed that she answered her helm quickly, turned in a small circle and a short time, and yet was perfectly under control in keeping an assigned course.

Turning to the armament, it is proper to note the fact that it is exceptionally heavy and powerful for a ship of such moderate size; and that the mountings are of a very novel character, representing some of the latest products of the famous Elswick factory. It includes two 25 ton 10 inch breech-loading guns; six 4 ton 6 inch breech-loading guns; two rapid fire 6 pounders, of Captain Noble's design; and a number of machine guns. The 25 ton guns are mounted as bow and stern chasers, and have an arc of training of about 240 degrees—120 degrees on each side of the keel line. They are carried on central-pivot mountings, and fire over a "glacis" formed by the ends of the upper deck. The engraving opposite illustrates the nature of the mountings. On the rear of each slide is a strong steel screen protecting the captain of the gun; and within the shelter of this screen is placed the hydraulic and other gear by which the gun is trained, moved in or out, elevated and depressed. Hydraulic mechanism, of Elswick design and manufacture, is employed for these heavy guns, and used for loading as well as working them. A very few men thus suffice, and these are well protected from rifle and machine gun fire. One important feature in the arrangement is the strong steel loading station built in rear of each gun. This is really a large steel house, within which are the upper ends of steel tubes, extending down to the magazines and shell rooms. By means of hydraulic hoists the projectiles and cartridges are lifted through the tubes into the loading stations, being sheltered in their transit. Having reached the loading station, the gun is laid fore and aft, and run in on the slide, being elevated for the purpose of loading. After the breech piece has been withdrawn, the projectile and powder charge are rammed home; and throughout the operations the powder is protected from rifles and machine guns. With large charges exceeding 2 cwt. of powder for the 10 inch guns, this is a matter of great importance. The penetrative power of these 10 inch guns is represented by 21 inches of iron armor; and both of them can be fought on either broadside, as well as being used for chasers.

On each broadside there are also three 6 inch 80 pounders, carried on central pivot automatic carriages, and having a horizontal range of training of about 130 degrees. This large arc is obtained by carrying the guns on projecting galleries. These guns require very few men for their crews, and there are strong steel protecting screens on the front of each slide to shelter the crews from rifles and machine guns. Similar protection is provided for the crews of the rapid-fire and machine guns. In fact, no one can inspect the armament without having impressed upon him the importance which the designers of the gun mountings have attached to defense against an enemy's auxiliary armament. Nor can there be any doubt that these provisions are wise and well considered, such protection being essential in a ship carrying her guns in the open on her upper deck.

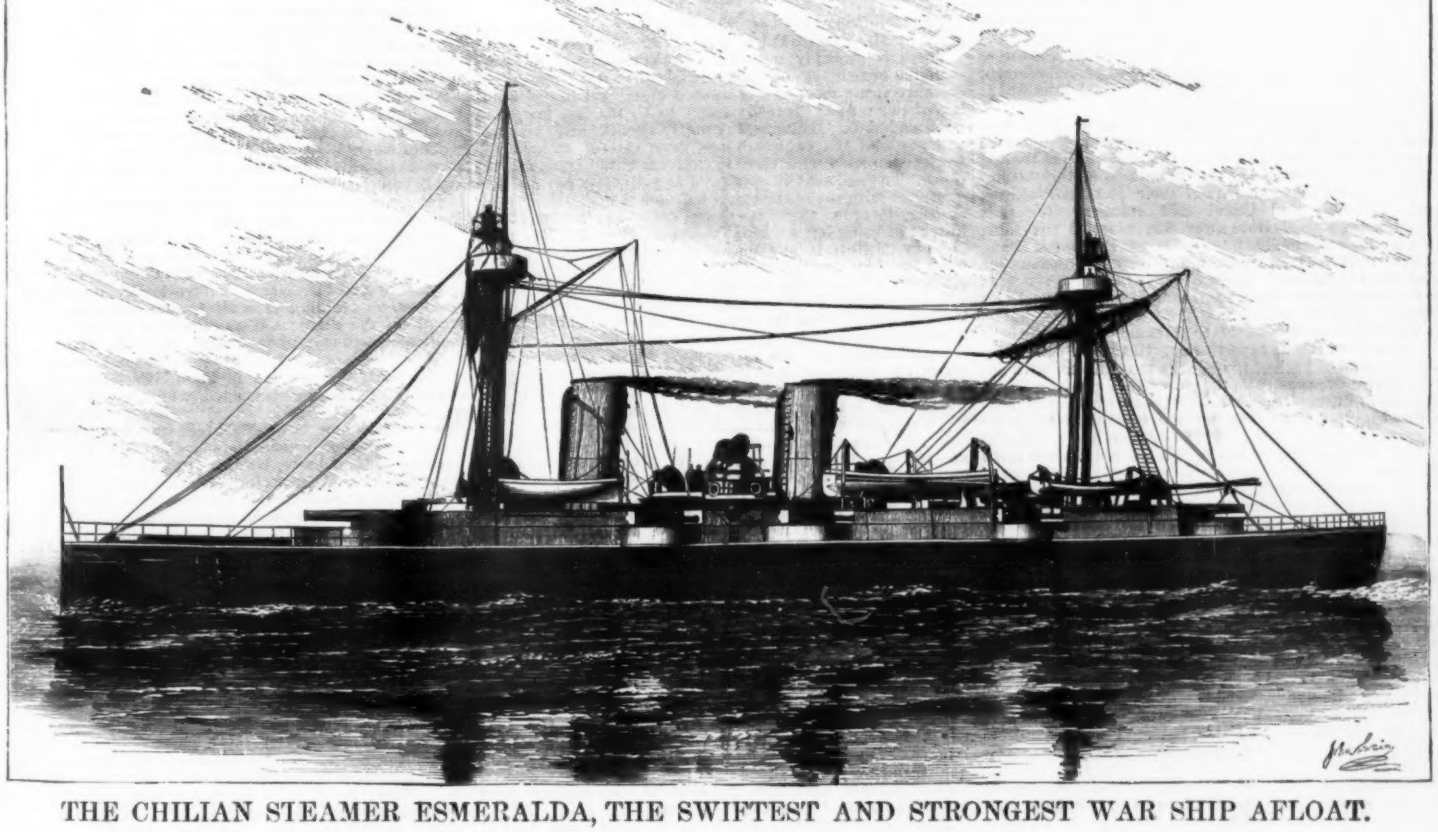
The Esmeralda has also a very good auxiliary armament with which to deal blows upon an enemy similar to those against which her men are exceptionally well protected. Her rapid-firing 6 pounders are of Elswick design and manufacture, capable of delivering fifteen to twenty aimed shots per minute, and of firing all kinds of ammunition. Carried on the bridge ends high above water, and furnished with mountings of excellent character, these guns are certain to prove useful in an action. Besides these guns, there are several Hotchkiss and Gatling guns on the bulwarks, and a Gardner gun in each of the military tops on the mast-heads.

The auxiliary armament will be of service against torpedo boat attacks, which usually happen at night. Electric search lights are fitted to assist in the defense against such attacks. They are two in number, and carried on light platforms on the mast-heads a few feet above the tops. The dynamos used for these search lights are also made available for internal electric lighting under ordinary conditions. These installations have been thoroughly tested, and found very satisfactory.

It will be obvious from the foregoing remarks that the Esmeralda is in all respects a typical ship of her class. She has been rapidly constructed, and her cost was comparatively moderate. Her armament is powerful enough to be used successfully against a large proportion of the armored vessels afloat; and her speed is so much in excess of that of armored ships that her captain could avoid an encounter if he thought the risks too great. Some authorities maintain that the construction of protected cruisers will lead to the abandonment of armor-clads; but, whether this be true or not, every one will admit that the Chilian naval authorities have acted wisely in authorizing the construction of the Esmeralda, and that other navies, more especially the British Navy, need a large number of vessels of a similar type. A beginning has been made with the Mersey and Severn class; yet, in view of what is being done by Italy, France, and other maritime powers, it may be questioned whether sufficiently rapid progress is being made with these protected cruisers. When the Royal Commission on the state of the navy begins its work, this is one of the subjects that must claim its consideration; and the sooner such an inquiry begins the better it will be for the national defense.

One of our engravings shows the central pivot automatic carriages and slides of the 6 inch 80 pounder breech-loading guns carried on the broadsides of the Esmeralda. The guns and mountings, it need hardly be added, are of Elswick design and manufacture. In the engraving the gun is shown at extreme elevation, and run out into the firing position. On the front of the slide is carried the thick projecting steel shield, which shelters the gun crew from rifle and machine-gun fire. The recoil presses are on the top of the slides. On trial the recoil was less than 18 inches when battering charges were fired. After recoiling, the gun returns automatically to the firing position. This mounting can be used as either center pivot or front pivot, and it can be readily transported across a deck if desired by means of the adjustable rollers upon which it moves when training. In the drawing the slide is simply chocked up; for the appearance of the mounting when in full working order, reference may be made to the engraving of the 25 ton stern chaser. A very small number of men suffices to work the guns of the Esmeralda, and the mounting was greatly admired by the officers of the Royal Navy who attended the trials.

Sir W. G. Armstrong, Mitchell & Co. have in hand at the present time three other powerful protected cruisers. The Giovanni Bausan, for the Italian Navy, is practically a sister-ship to the Esmeralda, but somewhat larger, rather better protected, and with an armament of Whitehead torpedoes. She is nearly complete, and will leave for Italy shortly. Her design has been adopted, with a few modifications, by the Italian authorities, for three other cruisers they are building at home. The two remaining cruisers are for the Japanese Navy, and have been designed by Mr. W. H. White, formerly Chief Constructor of the Royal Navy, but now a member of the Elswick Company. They are about the same size as the Leander class of the Royal Navy, or the Mersey and Severn; and in protection, armament, speed, and coal endurance take rank as the most important vessels of the class yet laid down. These vessels are being pushed on very rapidly, and will be probably completed next year or early in 1886.—*The Engineer.*



THE CHILIAN STEAMER ESMERALDA, THE SWIFTEST AND STRONGEST WAR SHIP AFLOAT.

EARLY RAILWAY HISTORY.*

By Clement E. Stretton, C.E.

There seems to be a very general impression that railways came suddenly into existence as a complete system at the time when the Liverpool and Manchester Railway was opened in 1830, and little or no attention is paid to previous history, or to the reasons which led to the various improvements and inventions.

The railways of to-day owe their existence to, and are the result of, the wonderful development of ancient tramways or railroads.

The discovery that a horse could draw a much greater load upon a hard level surface than upon an ordinary road led to the introduction of "stone tracks," which consisted of long narrow flagstones placed in parallel lines, upon which the cart-wheels ran.

About the year 1630 a Mr. Beaumont went to Newcastle-on-Tyne, and to facilitate the conveyance of coal from the collieries to the docks or shipping places, introduced the "wooden way," consisting of cross sleepers placed about two feet apart, upon which were nailed wooden planks or rails, six feet long and about four inches wide. He likewise introduced four-wheeled wagons in place of the ordinary carts, and in the "Life of Lord Keeper North" it is mentioned that "the carriages is so easy that one horse will draw down four or five chaldrons of coals, and is an immense benefit to the coal merchants."

A book published by Mr. Gray in 1649 records the fact that poor Mr. Beaumont, in a few years, lost £30,000 which he "adventured in the mines."

The wagon-wheels in course of time wore away the upper surface of the wooden rails, and the next fact on record is that, instead of replacing the old ones, new planks were nailed upon them, and this plan was again followed by plating the wooden rails with sheet iron, or by nailing iron plates or bars upon them. These became known as "plate-ways," and the men employed to lay them down as "*plate-layers*," and this latter word, as we are all aware, remains in use to this day, but the difference between the *plates* of old and the present steel rails, thirty feet long, weighing 85 lb. per yard, is striking indeed.

The plated rails, as we might expect, very soon caused considerable wear to the wooden wheels, and about the year 1753 it appears that cast iron wheels were introduced.

In 1767 Mr. Reynolds, one of the partners in the Colebrook Dale Iron Works, Shropshire, suggested that the wooden-plated ways should be entirely superseded by a cast-iron rail or plate, and that, in addition, an upright ledge or flange should be cast upon it, for the purpose of keeping the wheels upon the line. These rails were three feet long, four inches wide, with a flange on the inside, three inches high at middle, and two and a half inches at the ends, fastened to wooden cross sleepers by a nail or spike driven through a hole, formed by a small square piece being left out in each end of the castings. From the books of the Colebrook Dale Company it appears that, on the 13th November, 1767, between five and six tons of rails were cast, and at once laid down as an experiment. At first, it seems, they were not successful, being frequently broken. A flange, or rib, was therefore adopted upon the under side to give additional strength, and in the following year (1768) we find that the wagons were considered too large and heavy. These were, therefore, replaced by a number of smaller ones coupled together, thus reducing the weight upon any one rail, and distributing it over several yards of the way.

In 1776 a similar cast-iron rail was laid down by Mr. John Curr, at the Duke of Norfolk's colliery, near Sheffield, and it has been claimed that it was the *first* of the kind, but the date at once shows that such a claim is an error, as the Colebrook Dale experimental line had been at work for nine years. It appears that the laboring people at the colliery did not understand the great future of the iron way,

* Read before the Leicester Branch of A. Soc. of Railway Servants, November, 1884.

for they got up a riot, tore up and broke the rails, and burned the sleepers.

One of the greatest improvements was introduced, 1789, by Mr. William Jessop, when constructing a railroad at Loughborough, in Leicestershire. This engineer decided to abandon the flat wheels and flanged rails, and to introduce iron rails with a flat top, and wheels with a flange cast upon the tire. Mr. Jessop's rail was known as the "edge rail," because the wheels ran upon the upper edge. These rails were of cast iron three feet long, having a single head one and three-quarter inches wide; they were of the "fish belly" pattern, that is, deeper in the center than at the ends, it being considered that it combined the greatest strength with the least expenditure of material; they were fastened to cross sleepers by iron pins or bolts passing through a projecting base cast at the ends of the rails. It was soon found that the cast-iron projections were broken off, and the rails rendered useless, as there was then no way of fastening them; this led to a great and important improvement. The base was removed from the rail itself, and cast as a separate "chair or pedestal;" the plan of bolting the chair to the sleeper, and fastening the rail by means of a key driven between it and the chair, is in use to this day.

In 1797 Mr. Barns, when laying down a railroad at the Lawson Colliery, Newcastle-on-Tyne, introduced "stone blocks" instead of wooden sleepers, and in 1800 Mr. Outram also used "stone blocks" upon a line he laid from the collieries near Little Eaton, Derbyshire.

The dates plainly show that Mr. Outram was not the first to adopt the "stone blocks," but nevertheless he obtained all the credit, for this description of line was called the Outram road or way, which very soon became shortened into "tramroad" and "tramway."

In 1801 the Surrey Iron Railway Company obtained an act, and afterward speedily constructed a tramroad from Wandsworth to Croydon; and Sir Richard Phillips wrote: "I found delight in witnessing, at Wandsworth, the economy of horse labor on the iron railway, and thought such lines should be extended from London to Edinburgh, Glasgow, Holyhead, Milford, Falmouth, Yarmouth, Dover, and Portsmouth." The idea that railways should be laid over the country was generally considered perfectly absurd. An important tramway was also laid in Derbyshire, known as the Peak Forest line; and another at Ashby-de-la-Zouch, in Leicestershire, this latter one being of special interest, as part of it remains in use at the present time.

The Ashby Canal Company, under an act of 1794, constructed a canal from Ashby to Coventry, and obtained powers to extend it to Ticknall and Cloud Hill Lime Works, etc., but the directors, seeing the advantages of the "tramroad," abandoned the latter part of their plan, and laid the Ashby, Ticknall, and Cloud Hill tramway, the rails employed being of cast iron, three feet long, of the same pattern as those originally introduced at Colebrook Dale, and above referred to. These old tramroads became the property of the Midland Railway, by virtue of an act of 1846, and one part has since been altered and absorbed into the Ashby and Worthington Railway, but the branch from Ticknall tramway wharf to Ticknall has never been relaid or altered in any way, and, therefore, is a most interesting relic of ancient times. To see wagons with flat wheels, drawn over cast iron rails one yard long, by a horse, cannot fail to interest those who watch the working of railways; and it most clearly shows the great improvements made, and the perseverance which has been required to develop the present gigantic railway system out of such small beginnings.

In 1805 wrought iron rails were tried at Newcastle-on-Tyne, but they did not come into general use till about 1820, when the "fish belly" pattern, fifteen feet long, weighing 28 lb. per yard, became the most approved design. Up to this time the tramways had been worked by horses, and the locomotive engine was quite in its infancy.

Watt, in 1759, had suggested the application of steam power to wheeled carriages, and he took out a patent in 1784. His assistant, William Murdoch, in the same year, made a working model to run on a road.

In 1802 Richard Trevethick and Mr. Vivian were the first to introduce the locomotive on railways as a non-condensing engine. The adhesion between the wheels and the rails does not appear to have been understood at that time, for in 1811 we find Mr. Blenkinsop, of Leeds, patented the rack rail and cog-wheel gear, which was quite unnecessary, as it was afterward found.

Several engineers had now turned their attention to the locomotive engine, and in 1814 George Stephenson constructed an engine at Killingworth Colliery; it ran upon "edge rails," had flanged wheels, and two eight-inch cylinders.

The Stockton and Darlington Railway scheme was one of the important turning points in the railway history. George Stephenson was appointed engineer, and application was made to Parliament in 1818; twice the bill was rejected, but it passed in 1821, and on the 27th of September, 1825, the line was opened. It was not at first intended to work this railway by locomotives, and some fixed engines and ropes were provided, but the locomotive quickly proved its superiority over all other systems.

The "gauge of rails" may here receive attention, as the question has been asked why 4 ft. 8½ in. was adopted.

There can be no doubt that the usual width of the old wooden and cast-iron tramroads practically determined the gauge of our present railways. The usual width or gauge of these old tramroads was *five feet* over all, that is, including the width of the two rails, and, as Jessop's edge rails and the Killingworth tramroad had rails one and three-quarter inches wide, it is easy to see that the width of two such rails deducted from five feet leaves 4 ft. 8½ in. between the rails, or what we now consider the national gauge. George Stephenson saw no reason to alter the gauge, therefore, he adopted 4 ft. 8½ in. for the Stockton and Darlington and the Liverpool and Manchester Railways, and when consulted as to the gauge for the Leicester and Swannington, and the Canterbury and Whitstable railways, he replied: "Make them of the same width; though they may be a long way apart now, depend upon it they will be joined together some day." The "fish belly" rails, fifteen feet long, were adopted for all these lines.

It has been already mentioned that the "edge rail" was invented in 1789; it did not, however, come into general use for a number of years, as many persons preferred the old "plate rail," and in cases where two systems joined, a very useful rail was adopted, which consisted of a high side and a low one; wheels with flanges ran upon the high or edge side, and the flat wheels on the low one. These rails were of wrought iron, in fifteen foot lengths, the ends being dovetailed together. They were sometimes spiked direct to the stone blocks, but more generally placed in shallow iron chairs and keyed.

This double form of rail was first adopted at Coleorton Junction, where, by virtue of an act of June, 1833, a connecting line was made between the Leicester and Swannington Railway and the old Ashby tramroad.

The Liverpool and Manchester has been truly designated as the Grand British Experimental Railway. George Stephenson was the engineer, and the line was opened to the public 15th Sept., 1830; the rails weighed 35 lb. to the yard. Some time before the opening, the question of locomotive or fixed engines and ropes naturally came before the directors, as it was necessary to arrange for working the line; and, notwithstanding reports, the directors did not feel able to come to a decision, when one of their number—Mr. Harrison—proposed that "a reward be publicly offered for the most likely mode of effecting their object;" and on the 20th of April, 1829, it was resolved to offer a premium of £500 for the best locomotive engine, subject to eight conditions as to weight, load, pressure of steam, price, etc., and the offer was made on the 25th April.

October 1, 1829, was fixed for the trial, but was subsequently altered to the 8th; the running ground being on the Manchester side of Rainhill Bridge; and the following engines were entered for the prize:

ENGINE.	MAKER.
The Rocket	G. Stephenson.
The Novelty	Baithwaite and Erickson.
The Sans Pareil	Hackworth.
The Preseverance	Burstall.

The result of the trial (which lasted from the 8th to 14th October) conclusively proved that the Rocket of Mr. Stephenson was the best engine, and the prize of £500 was consequently awarded, as it had performed all the conditions and stipulations required by the company. It will thus be seen that the Rainhill trials of 1829 settled the locomotive question, and led to the introduction of railways throughout the world.

DRAINAGE FOR RAILWAYS, ROADS, ETC.

The following excellent directions for road drainage are given by Mr. Charles Paine in the *Railroad Gazette:*

There is probably no written work treating of the construction of roads or of railroads in which the necessity of drainage is not more or less insisted upon; yet in the building of our railways it really seems to be the last matter to be attended to. Examine any newly opened road, and you will see that the engineers have been careful to have the works completed with care, to conform to the standard sections. The assistant in charge of any division has possibly quarreled with the contractor a half-dozen times about each cutting, in order to get the slopes dressed to a true plane, instead of being left a warped surface. It would be a marvel, nevertheless, if any measures had been taken to preserve the slopes, or the ditches at the bottom of them, which are relied upon to drain the ballast. Generally the first hard rains of spring, aided by the thawing of the frozen earth, suffice to break down the slopes, fill up the ditches, and reduce the force engaged upon maintenance of way to a condition of despair; for the ballast must become saturated with water, the outer portion of it gets filled with mud, destroying its usefulness in great part; it is not unusual for the track to be floated by the mud and water before the ditching train can remove enough of the sloughing banks to enable the water to run away at the sides of the cut. Matters are the worst in clay cuttings, of course, although bad enough in any wet soil; that is, in any soil which does not drain itself, as sand or gravel will do if the clay substratum is not too near. If the sloughing is very bad, it is probable that a heavy stone wall will be decided upon as the proper thing to hold the slopes back; or, where stone is scarce, the pile driver will be called into requisition to drive a stout row or two of piles to resist the forces of nature; but the cause of the sloughing is unaffected, and continues to undermine the banks, frequently topples over the wall, and after a few years surmounts the piles or crowds them into the cut.

Meanwhile, the mud-train has had to struggle each fall and spring with the mud which would get over, through, or around the protection which had been erected.

Now, in most cases, all this trouble could have been avoided, the perfect form of the slopes and ditches, as well as the integrity of the ballast, would have been preserved, and no one would ever have thought of building a slope wall or driving piles to hold back the mud, if the engineer who built the road had looked to the drainage.

It may be broadly stated, as a general proposition, that if the water is removed from any bank of earth, that bank will stand at a slope of one and a half to one, the usual earth slope, or at a steeper angle; if the water is not removed from a wet bank, the slope will take a flatter angle, depending upon the degree of its saturation. The most effectual mode of removing the water from a wet cut is the cheapest one to adopt; but remove the water you must, if you wish for peace and quiet. It is best to begin at the top; most railroad men begin at the bottom; because that is nearest to the track, it may be supposed. If the cutting is through sloping ground, as most cuttings are, one side of the cut will be exposed to the flow of water from the ground above it, which should be intercepted by a ditch at the top of the slope; a short distance back from the edge is the best. If the surface soil is porous, resting upon a clay subsoil, the ditch should be lined, if possible, with cement or bitumen, or with plank, if necessary; the object being to catch the water and *carry it away*, as an eave-trough does, not letting it soak down into the clay below, which is usually too wet already.

The next place to give trouble is the foot of the slope; the water which falls upon the slope, that which percolates through the bank, and that which comes from the ballast, unite to soak, and thereby to soften, the earth at the bottom of the slope, which has to sustain the entire load of the hill above, which it can do only so long as it is dry and consequently firm; as soon as it becomes soft, it must yield to the pressure from above. Get this water away as quickly as you can; you cannot be too quick about it. If your cut is upon a very steep grade, it is possible that you may be able to run the water off in the ditches, at the foot of the slopes; if on any ordinary grades, the best way is to lay tile drains in the bottom of the ditches at a depth, say 5 ft., sufficient to have them secure from frost, and so ready to work continuously day and night, summer and winter, which they will do if put below frost. If any springs are discovered in the slopes of the cutting, they should be piped into the main drains which you lay in the bottoms of the ditches; if the whole is wet, it can be perfectly drained by lines of small tiles laid diagonally down the slopes, at intervals of from 20 to 40 ft., according to the amount of water to be taken care of. A little experience, with a little good judgment, will enable any one to proportion the sizes of tiles used to the length and wetness of the cutting to be drained. Beginning at the mouth of a cutting with tiles of 5 in. in diameter, they may diminish in size to 3 in. at the summit of the grade to which the tiles are laid, or at the upper end of the cut. Two or three lines of tiles may be laid in the same trench if the quantity of water requires more room than is afforded by one line. The lines for piping off the water in the slopes should not be of less than 2 in bore. The drain tiles of round section are the best, as least likely to be removed out of line, as a little reflection will show. They are frequently made with flat bottoms; these, if canted or rolled over by any cause, must get out of line, and so interrupt the continuity of the drain. They should be one foot in length; the frequency of the joints is an advantage, as it allows the water to get readily into the drain. Whoever begins the use of drain tiles will suppose that he must provide some porous material, like gravel, to cover them with, in order to afford a free passage for the water into the drain; but he need have no anxiety about that, for the water is bound to get in if the drain is there. A good stiff clay is the best covering for the tiles, as it does not wash nor fall into them at the joints as fine gravel does. In some very soft quicksand cuts, in which the fine sand filled the titles rapidly, destroying their usefulness, a thick sod was laid in the bed of the ditch, the grassy side up; the tiles were laid in this and covered with another sod, grassy side down; the ditch was then filled up with earth. The result was a very successful drain. When round tiles are used, the bottom prepared for them should be semicircular and as nearly as possible of the exact size of the tiles, which is easily accomplished by having tools of the proper form and dimensions. The men who are accustomed to laying these drains have acquired much skill, and in ordinary soils do not disturb or handle any more material than is necessary to allow the insertion of the tiles; they will often make an opening of less than one foot in width at the top of a ditch 5 ft. deep; and they will contract for laying such drains at a price per rod which will astonish the inexperienced engineer or track-master. If an expert can be got to superintend the first operations, he will be cheap at almost any price; yet no one who will act upon these hints can go far wrong; nor will the cost of his work be anything like that of not draining his road bed, if it is wet. When the drain is completed, if he will notice the flow of water from it and calculate the quantity which flows out each day, and consider that it never entirely ceases, he will begin to wonder where it all went to before the drain was built, and he will be entirely satisfied that the cost of the drain was small compared with the resulting benefit. In a double-track cut, perfection of drainage is secured by laying another line of tiles between the tracks.

If, in summer, there should be little or no water passing through the drains, the moles, snakes, and even muskrats will harbor in the ends of them, obstructing them with their nests. To guard against such intrusions requires some precautions, as building a small trap or catch basin near the mouth of the drain; a U-trap has been used with success, made of baked clay like the tiles. All such devices require to be cleaned out frequently, for the mud brought down in the water is deposited in them; if not cleaned out, the drains would become obstructed, which would injure them seriously.

In very wet cuts, where the quicksand flows in faster than it can be removed, a good drain can be laid of poles, roughly trimmed of their limbs, laid heads and points, so as to keep the drain of uniform section. Such a drain, from 12 in. to 18 in. square, will pass a great quantity of water, and one in each ditch will drain almost any cutting; if there is plenty of water, it will last forever and keep itself clear; if there is not a large flow of water, it will soon become filled up.

Let any person in charge of roadway select his wettest cutting for experiment, if he has any doubt as to the efficacy of the mode of drainage here recommended; and he will certainly find his track lie as still in the winter, in an excavation so drained, as if it were on a bank of gravel. But it is not important to use the methods here described; it is of vital importance to get rid of the water, in one way or another.

The drain tiles will be found of inestimable value for the drainage of large station yards where ditches would be inconvenient, and even in such places as will admit of surface ditches, because they can and should be placed deep under the surface; for it is of great benefit to remove all water to a distance of 5 or 6 ft. from the ballast upon which the tracks lie. Capillary attraction will raise moisture from 5 ft. in depth, in sand or loam; and when freezing weather begins, the drier the ballast and the soil upon which it rests may be at the depth to which freezing extends, the less heaving of the ground there will be, and consequently the slighter will be the disturbance of the track. In bad soils, the grounds surrounding shops, engine houses, and station buildings are wet and uncomfortable in autumn and spring, or in any wet weather. This may be completely prevented by tile drains, provided an outlet for them can be secured. Of course, the more fall there is for any drain, within reasonable limits, the better for the drain; yet even when carried level they will do a great deal of good. By their use, the thickness of the ballast or of gravel under tracks and around stations may be reduced about one-half—an economy which will pay well for laying the tiles, where ballasting materials are scarce.

Among the most difficult places to maintain in busy yards are the crossings of tracks, particularly those that cross nearly at right angles. Knowing this, the person in charge of the track generally excavates deeply at such a point, and fills in with broken stone or with the best material he can get, providing in this way an excellent drainage well for the adjacent road-beds. If he will supplement his labors by laying drain tiles in each direction through the bed of ballast which he has prepared for his crossing, taking care to give them a free discharge, he will find that he will need do nothing more for that crossing until it is worn out. Some idea of the quantity of water discharged by these drains may be conveyed to the inexperienced if they will notice the flow from the eave-spouts of a small shed during a smart shower, and remember that an equal volume of water falls upon the same area of track or yard, soaking the ground permanently, if means are not provided for its removal. A perfectly dry cellar under a warehouse in a wet clay soil was secured by the use of these drain tiles; and in another instance they maintained the bottom of the pit of a transfer table in an excellent dry state. A water station was secured near a very wet cut by turning the drain into a cistern; and it happened in this case, as it might in many others, that the cistern afforded the most convenient outlet for the drains that could be had.

There are thousands of miles of imperfectly ballasted or wholly unballasted road-bed in this country, lying near the natural surface of the ground, which would be rendered passably safe against the worst effects of wet and frost, if only a deep ditch were dug on each side of the road-bed to allow the water falling on the surface to flow quickly to a considerable depth below the surface on which the sleepers rest. The chief reason why broken stone and gravel make the best ballast is that they permit the water to pass through and to flow away from them so rapidly; if other materials can be so treated as to approximate to their condition, they will approach just so nearly to them in value for supporting the track. On poor railways, where expenditures must be kept at a minimum, and where the track-master is allowed only men enough on each section to operate the hand-car, it often seems quite impossible to get any ditching done, however sore the need. The section foreman's idea of usefulness and duty is confined to "keeping up the joints and centers;" he and his men are always tamping the ties and disturbing the road-bed, when they are not screwing up the joint bolts or riding over the section on the hand-car. These are important matters, of course, but they may be overdone, while ditching is left undone. Under this conviction, in the straitened circumstances which have been described, and determined that the necessary ditches should be cut before the autumnal rains, the section foremen, upon a hundred miles of new road in operation, were told that they must not touch a joint, neither surface nor tamp any part of the track, unless it became positively dangerous; they must devote all their time and energy to ditching; any foreman found doing anything except ditching would be dismissed, unless he could offer an acceptable excuse. These orders were issued in August, with the result that by the first of November the entire line was well ditched, at all important places, and the track passed through the winter and spring very comfortably, notwithstanding a lamentable want of ballast.

The neophyte placed in charge of a division of track should be warned that the section foreman of common mould always begins a ditch at the upper end, and, however well he may carry it on, he never opens the lower end of it, so that it may discharge freely, until the track-master finds the ditch full of water and orders the necessary outlet to be provided. It is best, therefore, to give special directions about this, in each case, to begin with.

The earth thrown out of the ditches should be evenly spread over the surface outside of them, making a gentle slope toward the ditch, whenever possible. The sooner this is done the cheaper it will be done; for freshly moved earth shovels much easier than that which has been consolidated by rain. When the earth has been spread in this way, the roadway can be cultivated or easily kept clear of brush and weeds, and as nothing is more discreditable than a disorderly roadway, this is a matter worthy of attention.

All this has no reference to what is considered the main drainage system of a railroad, which looks to provision for passing the streams and rivers safely through or under it; only on rare occasions over it. There are many large and scientific treatises on these matters, which should be studied before the tyro undertakes to act as engineer in their construction; yet there are a few hints not found in all the text books, which may be useful.

In this country, the habits of all streams are likely to be very much altered by the building of a railroad into any new part of it. Generally the marshes will be ditched, the woods will be felled, and other changes made, which will concentrate the flow of water into fewer channels than it originally flowed through, and it will reach them much quicker than it formerly did; consequently the water way provided for them should be very much greater than that which they would require if they could be expected to retain their original size. The very best judgment and the largest conceivable allowance may altogether fail (and often do fail) to anticipate to what dimensions any stream may attain; but as a minimum the following has proved a tolerably safe rule: Ascertain the area occupied by the stream, at its highest known flood; double this to arrive at the area to be provided before the water shall rise above its previous flood level, and allow at least a half more of room for extra floods, before your structure can be considered full.

But, however much room may have been provided, the labors of the engineer may come to naught from the neglect to construct or maintain a clear channel for the water to enter in a direct manner or to flow freely away from the bridge, or arch, or culvert. So often are these channels neglected, particularly under deep embankments, where it is somewhat difficult or fatiguing to visit them, that the track-master or superintendent who has some such structures under his charge, which he has not lately looked after, would do well to take a hand-car or special engine at once and see how they appear. They have been often found blocked with brush and floodwood, when they appeared clear and right from above; or the channel has begun to wash out at the lower end of a paving to a depth which the next flood would render dangerous; or the last flood started an opening into the embankment behind one of the wings, etc.; for all which evils there is an easy remedy, if taken in time; but after the next storm it may be too late.

THE WALDLITOBEL BRIDGE.

WE give herewith a few details as to the processes employed in constructing the Waldlitobel bridge, over which the Arlberg Railway crosses the Klosterle valley. This viaduct is established over a ravine 162 feet in depth, and whose sides are very precipitous. It has a span of 135 feet, and is immediately followed by a second arch of 26 feet span, as shown in Fig. 1. The process of mounting this work of art merits study, by reason of the difficulties that were met with through the nature of the ground.

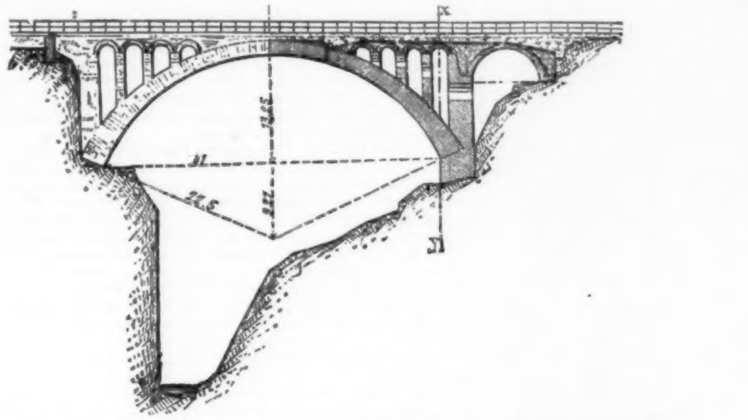


FIG. 1.—WALDLITOBEL VIADUCT.—LONGITUDINAL SECTION AND ELEVATION.

It became necessary, on this latter account, to construct a framework consisting of 5 trusses connected with each other by diagonal stays and cross braces. These trusses were spaced about 4 feet apart, and rested below upon posts connected with each other by diagonals and cross braces.

Over the deepest part of the ravine it was impossible to establish posts, and so it became necessary to construct an unsymmetrical trusswork, as shown in Fig. 3. Above the lower member of the framework there was established a bridge 16 feet in height that included 9 uprights spaced 16 feet apart. It was upon these uprights that were situated the sand boxes that served for striking the centers, and that supported the centering properly so called. The lower part of this latter was 6 feet above the line of the spring of the arch.

FIG. 2.—TRANSVERSE SECTION THROUGH $x\,y$.

On the Inspruck side the rock forms a natural abutment, while on the Bludenz side the abutment consists of solid masonry.

The arches of the centering, properly so called, rested upon cross timbers 12 inches square in section, and these in turn rested upon the sand boxes mentioned above.

The pitch of the centering was 37 feet. Its contour consisted of 8 plank-rafters, which were curved, and connected with each other by bolts. These rafters rested upon joists which were propped in the center and at the joints by struts. With the exception of the vertical timbers of the lower part, which were cylindrical and 12 inches in diameter, the framework was entirely of squared timber. The transverse pieces were 12 inches square in section. The upper stays, girders, strut-beams, and the wood that formed the arches of the centering were 10 x 12 inches, and the tension diagonals were 6 x 8.

For the construction of this framework 6,156 cubic feet of wood and 4 tons of iron were used. Its total cost was 10,000 florins.

The bridge, like all the art-works of the line, is intended for a single track. At the level of the cornice it is 20 feet in width, and at the upper level of the stringers of the railway, 15 feet. The road that it supports has a gradient of 30·44 per cent.

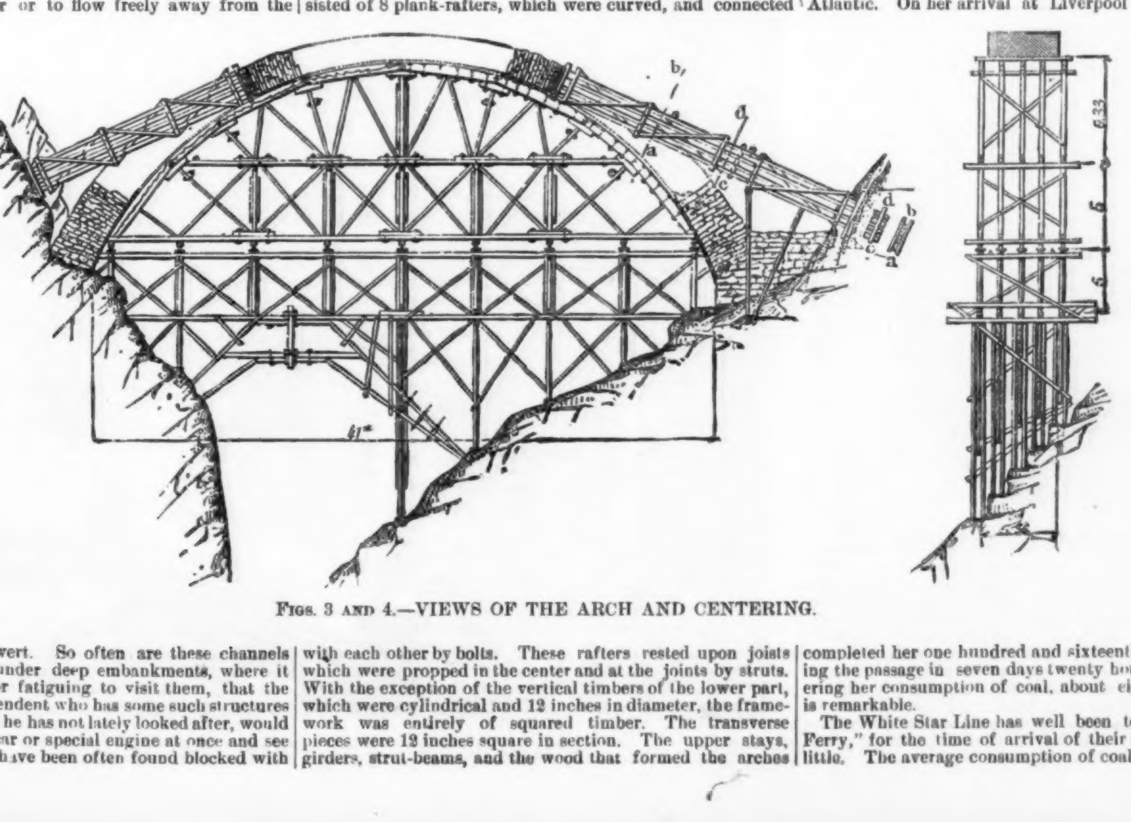
The principal arch has a pitch of 43 feet, and is constructed of rough-dressed ashlar. The mortar employed consisted of a mixture of 1 part calcareous cement with 2 parts of well washed quartzose sand.

The arch has a thickness of 5½ feet at the key, and of 10 at the abutments.

The work was begun at four different points, to wit, at the two abutments and at two places situated on each side of the center of the arch, as shown in Fig. 3. To effect this it became necessary to establish two artificial abutments consisting of a double framework formed of 12 timbers placed side by side. These abutments transmitted the thrust of the masonry to the rocky sides of the ravine through the intermedium of two stays each consisting of four timbers connected in the form of a grating, as shown in the transverse section, *c d*. This framework in no wise interfered with the construction of the arch, as may be seen by a glance at the figure. The arch was thus closed in three places. The closing of the key offered no peculiarity; but at the two other points it became necessary to proceed with much care, by reason of the previous removal of the artificial abutments.

The centering was removed six weeks after the masonry had been finally completed. The object of the quite original method of construction that we have just described was to prevent distortions of the arch, and it had the advantage of permitting the latter to dry regularly, and of notably shortening the duration of the work, since the masonry was laid at several points simultaneously.

Above the extrados of the principal arch, and at either side of the key, there were constructed four arches of smaller dimensions, forming the haunches. These are of 6 feet span. The bed consists of a layer of beton about 8 inches thick covered with cement and an impermeable layer of special composition. This latter is in turn covered with a new layer of cement about two inches thick, and finally with one of sand four inches thick. Different trials have shown that this mode of constructing the bed gives excellent results.—*Annales des Travaux Publics.*



FIGS. 3 AND 4.—VIEWS OF THE ARCH AND CENTERING.

STEAMER ADRIATIC.

THE White Star Line steamer Adriatic, Captain Parsell, arrived here at 6 P.M., December 4, 1884, from Liverpool, making the run from Queenstown in about eight days. This voyage is her two hundred and thirty-third across the Atlantic. On her arrival at Liverpool November 15, she completed her one hundred and sixteenth round trip, making the passage in seven days twenty hours, which, considering her consumption of coal, about eighty tons per day, is remarkable.

The White Star Line has well been termed the "Ocean Ferry," for the time of arrival of their steamers varies but little. The average consumption of coal on the White Star

boats is less than one hundred tons per day, and this makes their regularity all the more noteworthy. The steamers are all fitted up in magnificent style.—*N. Y. Jour. of Commerce.*

A METHOD OF SINKING THROUGH QUICKSAND BY ARTIFICIAL FREEZING.

AT the monthly meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers, held at Dudley, Mr. Henry Johnson, Sr., in the chair, Mr. Herbert W. Hughes, A.R.S.M., read a paper on this subject. He said: Mining engineers are generally interested in the question of traversing very water-bearing ground. It frequently happens that valuable seams are overlain by ground of this kind, and it has to be sunk through before they can be reached. In carrying a sinking through beds of quicksand or loam saturated with water, an enormous pressure develops itself against the timber set to support the sides of the excavation, since the cohesion between the particles of the rock is very small. A necessity for strong timbering therefore arises, but this excessive pressure is not the only difficulty to overcome; when, as in quicksands, the spaces or voids between the particles are filled with water, the cohesion between the grains of sand is destroyed, the film of water surrounding each grain and the floating action of the fluid present in the interstices preventing friction. Hence it happens that if an opening is given to the fluid, the grains pass out with it, and it then becomes more easy to excavate than to prevent the formation of irregular empty spaces, which would give rise to intense unequally distributed pressures, which are difficult and sometimes impossible to resist. This fluid character of the sand constitutes a very great difficulty in sinking, because the issue of the sand into the excavation occasions the falling in of the sides and surface. When the water among the sand is under great pressure, the difficulty is enormous, and in some cases insurmountable. Thus at a sinking recently undertaken at a Belgian coal field, a quicksand was encountered at a considerable depth from the surface, after passing through the overlying beds without difficulty. As soon as this bed was struck, the fluid mass of sand and water rose so rapidly in the shaft that the sinkers had hardly time to escape. After contending with this eruption for a long time without success, the sinking was finally abandoned. Numerous other examples might be given, especially in the Northeastern coal district of England, and in the Ruhr and Mons basins; some were successfully completed, though at an enormous cost. Sinking through such strata is the most costly and uncertain among mining operations, and therefore a new method, which has already proved useful in a severe case, is a boon to mining industry, and seems to be applicable in a certain number of special cases.

The result is obtained by artificially freezing the ground in question, and after it is frozen one finds a solid mass, which can easily be cut with the pick, and presents no especial difficulty in its removal. This process, invented by Herr Poetsch, was described in 1883 in the *Bulletin de l'Union des Ingenieurs des Ecoles de Louvain.* The author of the note, M. Andre Dumont, says that the first idea was given some years ago by M. Lambert, in his lectures on mining at Louvain. This might be so, but there is no doubt that the credit of bringing the process into practical use belongs to Herr Poetsch, under whose direction the manner of proceeding has been successively practiced in the sinking of the Archibald shaft, near Schneidlinger, in order to work the lignite there. After sinking a little over thirty-seven yards without difficulty, the shaft reached a wet quicksand, which was proved by boring to be eighteen feet thick, the lignite being below this bed. The shaft was a rectangular one, fifteen feet six inches long, and eleven feet six inches wide. Around the circumference of the shaft a series of holes were sunk by means of a sand-pump; being tubed as they go down, and finally one was put down in its center. There were twenty-three of these pipes, of seven and three-fourths inches in diameter. When these tubes had penetrated through the quicksand, their lower ends were made water-tight by means of lead stoppers, these latter being covered with several layers of cement and tar poured into the interior. Into the center of each of these larger pipes a smaller tube of two and one-quarter inches diameter was introduced, having its lower end open; and also with side openings pointing toward the bottom. These latter pipes are provided with stop-cocks, and joined to a circular distributing pipe suspended above the bottom of the shaft. Down this a freezing mixture is pumped, and circulates in the annular space between the two tubes; by this means the ground between each pipe, then that within the shaft itself, and also the ground outside the limit of the shaft, is frozen hard enough to give it solidity. The freezing mixture used was a concentrated solution of the chlorides of calcium and magnesium, which freezes at a temperature of 45° C. In sinking the Archibald shaft the solution, cooled to a temperature of 25° C., by a manner described farther on, was forced by means of a pump into the pipes of two-and-one-fourth inches diameter, and ascended in the annular space between these pipes and those of seven and three-fourths inches diameter, rose to the surface of the quicksand, and was collected in a trough, from whence it again returned to the freezing machine at a temperature of 19° C. This low temperature on returning was not expected, and consequently the ground was soon frozen; of course the most intense cold was at the bottom of the pipes. As a result of this, small cones of frozen earth, with their bases downward, were first formed, the dimensions of which increase progressively; they cross one another and unite, forming ultimately a compact mass, the solidity increasing with the depth.

At the Archibald sinking, a mass of ground twenty-four feet wide, twenty-seven feet long, and eighteen feet thick was frozen into a solid mass in thirty days. In order to determine how the freezing progressed, pipes containing a solution of chloride of calcium were put into the ground, and thermometers immersed in them. In this manner it was possible to estimate the reduction in temperature during twenty-four hours. The total reduction was 30° C., viz., from an initial temperance of +11° C. to a final temperature of −19° C. We may, however, presume with certainty that a lower temperature was reached, because these observations could only be made in the upper part of the quicksand. Horizontal measurements proved that the freezing extended outward from the pipes for a distance of ten feet. After thirty days the workmen could proceed with the sinking; the mass of frozen sand and water possessed a hardness which allowed it to be easily cut with the pick; its fracture, as may be supposed, was conchoidal. During the sinking of the shaft the workmen were protected from an influx of quicksand by the frozen wall of ice around the dimensions of the shaft, this wall being able to withstand enormous pressure.

The manner of freezing the solution at the Archibald sinking was based on Carré's principle, the necessary machinery to carry it out being designed by Herr Kropf, of Nordhausen. It depends on the property of fluids absorbing a large quantity of heat when passing from the liquid into the gaseous state. The fluid used was liquid ammonia, which boils at 0° C. under a pressure of three and a half atmospheres, and at 20° C. under a pressure of 0·84 atmosphere. That is to say, ammonia, in passing from the liquid into the gaseous state, under a pressure of 0·84 atmosphere, reduces the temperature to 20° C. In a large boiler, placed in a convenient position, an aqueous solution of ammonia is boiled. The gas enters a condenser cooled with water, and is there submitted to a pressure of from ten to twelve atmospheres. At this pressure the gas liquefies, and is then conducted into a reservoir fitted with an indicator showing the height of the fluid in it. From this reservoir the liquid ammonia passes by a pipe into a spiral-shaped tube, where it once more volatilizes, and by so doing abstracts heat from the mixture of the chlorides of calcium and magnesium which surround the tube. The construction and working of the machine cannot be entered into here. Designs and full description will be found in the before-mentioned memoir by M. Dumont. The principle only is given. Further trials will no doubt confirm the favorable opinion already obtained by this ingenious process.

When Herr Poetsch first introduced this process he recommended the following arrangement of the pipes in the quicksand: Just before reaching the quicksand, the shaft should be widened out for a few feet over its proper dimensions. A row of pipes about three feet apart should then be placed around the shaft, slightly outside its area, another row should be placed inside the area of the shaft, and finally one should be placed in its center. This arrangement has never been carried out, as, owing to the prejudice of engineers, every other method of sinking through quicksand has been tried before recourse has been made to this one. This was the case with the Archibald sinking, and if Poetsch's method had failed, the undertaking would have had to be abandoned. It would be useful to know the cost of sinking by this manner, in order to compare it with the methods used till now in this class of undertaking, viz., sinking through quicksand. We, unfortunately, do not know to what extent the workman's health is affected by operations carried on in such a low temperature, but in the above example no evil effects occurred which were perceptible. Such a process at first sight appears incredible, and it would be a bold step to apply it to a sinking where a thick bed had to be pierced, but it cannot be denied that for short distances it has proved eminently satisfactory.

In concluding, I may remark that there is also the question of what material the lining of the shaft should consist of. At such low temperatures brickwork could not be used; if it was, it would immediately give way when the normal temperature was again reached. Even with wood tubing, the water in its pores would freeze and reduce its strength in a marked degree. The method adopted at the Archibald shaft was to first case the shaft with well-dried wood, and then, when the temperature of the surrounding strata had reached its natural condition, build up a coating of brickwork inside it.

CAST IRON ARCHED RIBS FOR MIDDLESBROUGH TOWN HALL AND MUNICIPAL BUILDINGS.

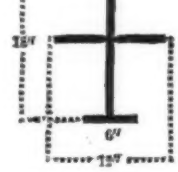
WE publish a copy of a photograph showing the remarkable cost iron arches which have been adopted in preference to wrought iron girders to carry the floor of the great hall of the new public building in Middlesbrough.

The size of the hall is 118 feet 6 inches long by 60 feet wide. The whole of the space underneath is intended to be used as a police drill hall. The floor of the lower hall is about $4\frac{1}{4}$ feet below the general pavement level, and the floor of the Town Hall is $10\frac{1}{4}$ feet above, thus leaving a height of 14 feet 6 inches from the basement floor line to that of Town Hall.

It was a *sine qua non* that the floor space of drill hall should not be impeded by columns, and as the width of the floor which had to be carried was 60 feet, a difficult problem presented itself as to how to accomplish the result desired without unduly lessening the height of the drill hall by using girders of great depth. It may be remarked that it was not permissible to increase the height of the story either by lowering the basement or raising the level of the floor of Town Hall. If ordinary wrought iron girders had been used for so wide a span as 60 feet, it would be necessary, in order to insure the rigidity that was demanded for so important a public room, to have their lower flanges not less than $4\frac{1}{2}$ feet below the Town Hall floor level. The net headway in the drill hall would therefore be only $9\frac{1}{2}$ feet. The effect of a succession of main girders of such a depth across a room 120 feet long would have been utterly ruinous to its appearance, so far as architectural effect was concerned, and in consequence it had almost been decided to give up the idea of dispensing with columns, with a view of lessening the depth of the girders, when an alternative scheme was suggested of constructing each main girder as a cast iron arched rib. This scheme was carefully worked out in detail, and it was found to be decidedly more economical than the first proposal of large wrought iron girders, and, in fact, not more costly than the objectionable alternative of using smaller wrought iron girders supported by columns.

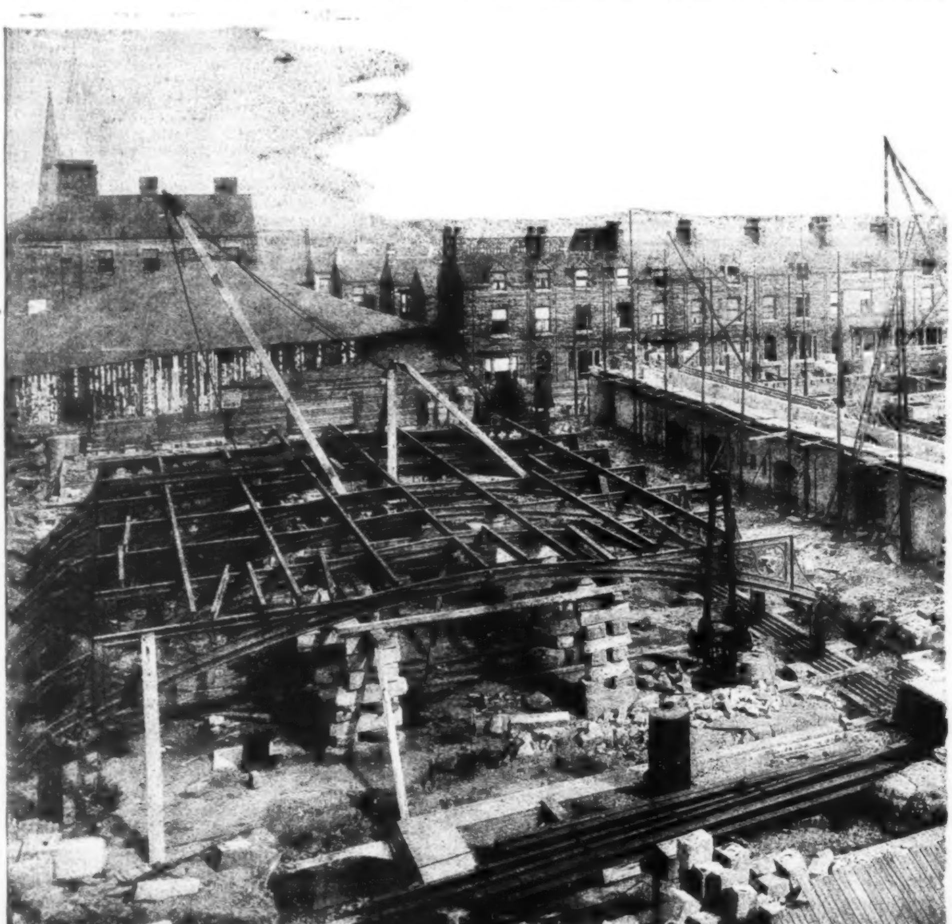
There were other advantages in favor of the arched plan. The total headway in the center of the drill hall is 12 feet 3 inches, or three feet more than was possible with wrought iron girders, while even at the abutments there is ample height to allow of the marching of men with fixed bayonets close to the wall. The whole of the floor space can therefore be used without any obstructions or inconvenience. The architectural appearance of the drill hall is no less improved than its utility. The perspective of light cast iron traceried ribs will have a most pleasing effect.

The general section of the ribs is 18 inches deep by 12 inches wide, the upper and lower flanges being less in width



than the middle one, and the thickness of metal varies from one inch to one and one half inches. The upper part of the rib however, at crown, is concealed in floor, so that the apparent depth of the rib below the ceiling line at that point is less than a foot. The spandrels of the arches are filled in with an effective arrangement of tracery in circles, enriched by quatrefoils. The larger circle will be further embellished with shields, displaying the arms of the corporation.

The estimated distributed load on each of the arch ribs is about 40 tons, while the lateral thrust at each external abutment under the load will be about 50 tons. As the point of



WIDE SPAN CAST IRON ARCHED RIBS.

abutment is several feet above the level of the external ground, it was necessary to make some special provision for buttressing the arch, and an ingenious arrangement for doing this was designed, which insures absolute security without in any way disturbing or modifying the architectural treatment originally proposed for the external and internal piers. The photograph shows the form of casting designed for this purpose, and it is sufficient to say that before the abutment can be moved the whole weight of the wall of the Town Hall must be lifted.

The architect for the building is Mr. G. G. Hoskins, F.R. I.B.A., of Darlington.

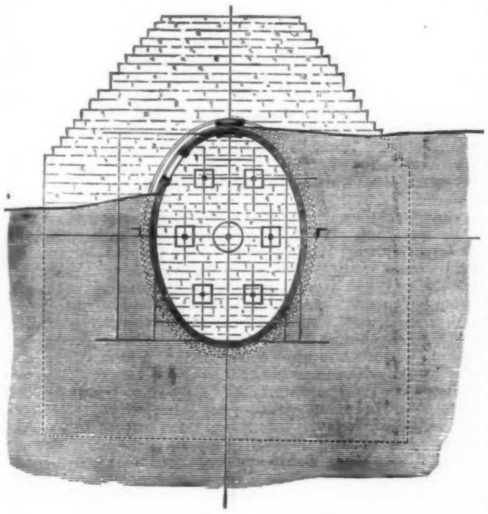
The engineering work above referred to (as well as the fireproof floor) was intrusted to Messrs Dennett & Ingle, of Whiteall and Nottingham, and has been successfully carried out by them. The castings are of a very superior quality, notwithstanding their great size, which is no less than 32 feet by 8 feet for the half ribs, and they have been cast without a flaw. The floor of the Town Hall, which the ribs are designed to carry, is to be of Messrs. Dennett & Ingle's well known method of fire-proof construction. In this case it will consist of rolled iron joists resting on the upper or horizontal flanges of the arched ribs, and gypsum concrete arches running lengthwise of the room, in spans of about 7 feet.—*The Architect.*

[NATURE.]

EXPERIMENTS WITH COAL-DUST AT NEUNKIRCHEN IN GERMANY.

DURING the course of the last summer the Royal Prussian Fire-damp Commission has carried out a series of experiments in the Saarbrucken mining district with the view of ascertaining the influence which coal-dust has, alone and in conjunction with fire-damp, in propagating explosions in mines. The apparatus and the mode of experiment were suggested by retired Bergwerks-director and Bergassessor Hilt, of Aix-la-Chapelle, who is a member of the Commission, and the results hitherto obtained have been of the most interesting kind.

The experiments are conducted at the Royal Coal-Mine, König, near Neunkirchen, where there is a blower of fire-damp at a depth of 131 yards below the surface. The quantity of fire-damp given off by this blower amounts to about 0·9 cubic foot per minute, consisting of 86 per cent. of light carbureted hydrogen mixed with air, etc. It has been in existence for the last two years. The fire-damp is brought



a distance of 1,200 yards in pipes, and collected in a small gasometer whose capacity is 176 cubic feet.

Dr. Ad. Gurlt of Bonn lately called my attention to the fact that over two hundred experiments made with this apparatus on a large scale had proved the correctness of my theory of great colliery explosions (*Proc. Roy. Soc.*, vol. xxiv., p. 354, etc.), and at the same time suggested that a visit to Neunkirchen would be of interest.

Accordingly I proceeded to the scene of the experiments on October 25, accompanied by Mr. Wm. Thomas Lewis, one of the members of the Royal Commission on Accidents in Mines, and we were met there by Dr. Gurlt, who had traveled from Bonn for the purpose, and by Herren Prietze, Nasse, Margraf, and Kreuser, directors and assistant directors of König Grube and other royal mines of the neighborhood. Herr Margraf, under whose superintendence all the experiments are and have been made, has most kindly furnished me with a detailed description of the apparatus and of the experiments witnessed by Mr. Lewis and myself, and I am glad to avail myself of, and shall endeavor to reproduce, his account as nearly as may be, allowance being made for the difficulties of exact translation.

The experiments are made in a horizontal wooden gallery 167 feet long, closed at one end, and having a horizontal branch gallery 33 feet long standing out at right angles to it at a distance of 93 feet from its closed end. Both the main gallery and the branch consist of elliptical rings of double T-iron lined internally with planks 1·6 inches thick, which abut closely together and are grooved and feather-jointed lengthwise. The greater axis of the ellipse stands vertically, and is about 5 feet 7 inches long; the lesser axis is 3 feet 11 inches. The main and branch galleries are both embedded in the pit-heap to such a depth that the rubbish is level with their top on one side and reaches to three-quarters of their height on the other side. Along the exposed part of the latter side there is a row of windows, thirty-two, in the main gallery, and three in the branch gallery, situated somewhat more than a yard apart. They are formed of sheets of glass about ⅝ inch thick set in cast-iron frames. There are also a number of openings in the top of the main gallery, one of which, near the closed end, is an ordinary man-hole, which can be closed by a man-hole door like that of a boiler, and serves as a means of ingress and egress. The others are circular, about 9 inches in diameter, and are lightly closed with wooden plugs attached to chains, which act as safety valves. All these openings assist in the removal of after-damp after an explosion.

The closed end of the main gallery is sunk about 3 feet 9 inches into a block of masonry whose dimensions are 12 feet 4 inches long, 9 feet 9 inches wide, and 13 feet high. Seven cast-iron cannon, with a bore similar to that of a shot-hole in hard ground, are built into the block in the position shown in the figure opposite, so that their mouths are flush with the face.

There are two holes near the top, two near the bottom, and three in the middle, grouped symmetrically in relation to the two axes of the ellipse. The middle hole is 37 inches deep by 1·57 inches in diameter; the others are 31½ inches by 1·37 inches in diameter. The axes of the two upper and of the two lower holes are placed in such a position that they form the angles of a four-sided regular prism whose apex is situated in the axis of the main gallery at a distance of 16·4 feet from the face. The axes of the three middle holes constitute a bundle of rays which meet at the same point as the last. Wooden hoops projecting inward from the sides are placed at various distances apart in the main gallery within the first 65½ feet from the face. By fastening cloth diaphragms to these hoops, compartments of various capacity can be formed, that of the first next the face being 705 cubic feet.

The shots are fired electrically with Abegg's fuses by means of an exploder made by Mahler and Eschenbacher of Vienna. The charge, which consists of 230 grammes, or about half a pound, of powder, occupies a length of 8·64 inches in the central hole, leaving room for rather over 28 inches of stemming, and 11 inches in the other holes, leaving about 20 inches for stemming.

The coal-dust is strewn upon the floor of the gallery from the face toward the open end in a layer of about 1·17 inches thick immediately before firing the shots. The weight of dust in each ten yards of length is about thirty pounds. It has been found in practice that, notwithstanding the upward direction of their axes, the shots next the floor produce the greatest disturbance of the coal-dust and give rise to longer coal-dust flames than any of the others.

In all the experiments witnessed by Mr. Lewis and myself, *one shot-hole only*, namely, one of the two next the floor, was charged and fired. The charge consisted of 230 grammes of blasting-powder each time, and the tamping was damp clay. Both ends of the branch gallery were closed with a double board brattice 1·96 inches thick.

In the first experiment neither coal-dust nor fire-damp was employed, and the flame of the shot was seen through the windows to be a little over 13 feet long.

In the second experiment a length of 65 feet of the floor of the main gallery was strewn with coal-dust from Camphausen Colliery in the Saarbrucken mining district. The shot gave rise to a loud detonation, and the resulting flame filled the gallery to a distance of 88½ feet. When the thick black after-damp had been drawn off by means of two of Korting's exhausters, placed over two of the safety-holes and worked with compressed air, it was found that the inner brattice of the branch gallery had been broken, and small globules of coke were observed lying on the surface of the remaining coal-dust.

In the third experiment a length of 130 feet of the floor of the main gallery was strewn with coal-dust from Pluto Mine in Westphalia. When the shot was fired, the flame traversed the whole length of the gallery with great velocity, and came out at the open end to a distance of 16 feet, being thus altogether 183 feet long. Notwithstanding the entire absence of fire-damp, this was a true explosion of the most violent kind, and the clouds of after-damp which streamed from every opening darkened the air in the neighborhood of the gallery for two or three minutes. The brattice at the inner end of the branch gallery had not been replaced before this experiment, and the one at its outer end was broken into small fragments, some of which were thrown to a distance of 115 feet. The flame was also seen to emerge from the branch gallery to a distance of several yards. The coal-dust remaining on the floor after the explosion was covered with a sooty film, in which coke globules were found embedded.

The brattice at both ends of the branch gallery was now replaced, and the floor of the main gallery swept clean as usual. In the fourth and last experiment, coal-dust from Pluto Mine was strewn on the floor for a distance of 65 feet from the face. A diaphragm of prepared canvas was fastened in the gallery at the point where the space inclosed between itself and the face amounts to 705 cubic feet.

A volume of 35¼ cubic feet of fire-damp was introduced into this space, and complete diffusion was effected by beating the air with cloths. The mixture of fire-damp and air thus obtained is not inflammable or explosive by itself, and shows a cap of only $1\frac{3}{16}$ inches high on the reduced flame of a safety-lamp. The firing of the shot produced a flame 190 feet long, accompanied by a report like a thunder-clap. The inner brattice of the branch gallery was broken, and drawn several yards into the main gallery, but the outer one remained intact.

Some idea of the great force of the two last explosions may be gathered from the following facts: An ordinary mine railway, beginning on a level with the floor of the main gallery, extends away from its open end in the direction of its length; and ascending at an angle of 4°. An ordinary mine wagon, loaded with iron so as to weigh altogether 15¼ cwt., was standing on the rails at the mouth of the main gallery when the shots were fired. When the third shot was fired, it was driven up along the rails to a distance of 23 feet, and when the fourth shot was fired, it was literally hurled along the railway by the force of the explosion to a distance of 52½ feet, being driven off the rails and running on the ground for the last six feet. The boards constituting the end of this wagon next the gallery were broken, but not torn off. A small beam 4 inches square, bolted across the rails at the mouth of the gallery, so as to form a stop for the wagon, was torn from the bolts which held it, and sent flying after the train. Lastly, a shower of stones and debris was raised by the blast which swept out of the mouth of the gallery, and some of the pieces carried upward of 100 feet.

The foregoing facts appear to me to be well worthy of the attention of all who have any interest in the prevention of explosions in mines.

W. GALLOWAY.

AN EASILY CONSTRUCTED CLEPSYDRA, OR WATER CLOCK.

IN different countries, and at various epochs, there have been constructed clepsydras, or hydraulic clocks, whose essential part was a vessel that filled with water and emptied again with the greatest possible uniformity and regularity. The successive heights of the water level in this vessel, which were registered by a graduation, indicated the time of day approximately, and with so much the more accuracy in proportion as the flow was better regulated. But, aside from the fact that such uniformity was less easy to obtain than conceived of, it was often quite troublesome to make up for the waste of the constantly renewed stream of water.

In a system communicated to *La Nature* by one of its correspondents, and which we illustrate and describe herewith, the liquid is not renewed, and the same volume of water, alcohol, petroleum, or other liquid serves indefinitely, like the weights of a clock, and the instrument is wound up just as easily.

The clepsydra, properly so called, that is to say, the chronometer (to say nothing about the alarm) consists essentially of a hollow cylinder, A (Fig. 1), of sheet metal, about a third full of any sort of liquid. This cylinder is fixed upon an

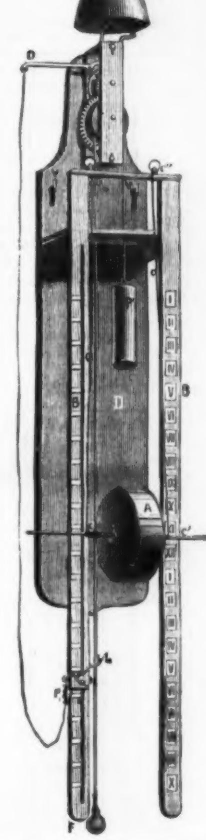


FIG. 1.—A SPANISH CLEPSYDRA.

axle that traverses its center, and at each side of it there is wound a fine cord which is attached by one extremity to the axle, close to the cylinder, and by the other to an upper point of suspension, C', dependent from a board that is designed to support the entire affair and be fixed against a wall.

It will now be seen that if the two cords unwind at the same time, and with uniformity, the cylinder, A, will descend, and that to measure such descent, and render it perceptible, it will be only necessary to cause the axle to make its way along a graduated rod, B. The divisions passed over are proportional to the duration, and will therefore give the measurement of the time. They are so much the smaller in proportion as the axle and cords are slenderer. On account of the weight of the liquid contained in A, the cords unwind slowly and uniformly, and the cylinder in descending does not move any more perceptibly than do the hands of a clock. In the annexed figure the axle marks 11¼ h.

As regards the internal arrangement of the cylinder, A, that will be understood by reference to Fig. 2.

The point of suspension, P, being to the right of the geometrical center of the drum, the latter tends to revolve in the direction shown by the arrow. The liquid in the interior does not follow the motion freely because it meets the pieces, A, A', A", which, however, do not absolutely prevent its motion, on account of the apertures, O, O, that they contain.

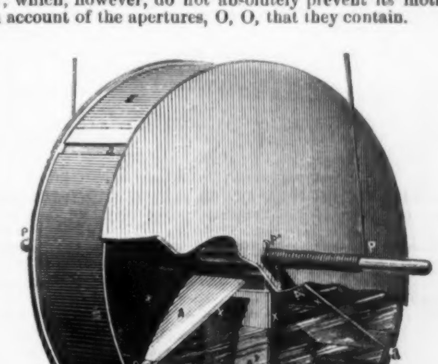


FIG. 2—INTERNAL ARRANGEMENT OF THE DRUM.

Instead of water, it is preferable to use a less congealable liquid, such as alcohol, petroleum, etc. This liquid is introduced through an aperture which is afterward soldered up.

To the axle of the drum there are symmetrically soldered two small brass rings to which are affixed the extremities of the two cords.

The drum is then placed in front of the rod, and the latter is graduated by observing the descent with a watch in hand.

The cords must be previously submitted to tension for some little time, so that they shall not become elongated. The hygrometric variations of the atmosphere and those of the temperature are of such a nature as to somewhat interfere with the accuracy of the indications, through their action upon the cords, but, as we have above stated, the instrument is *approximative*, it is not a chronometer of precision. As jarring and vibrations would accelerate the descent, they should be avoided.

To wind up the clock it is only necessary to revolve the axle between one's fingers, just as one would roll a cigarette. As regards the construction of the drum, that is very simple. We begin by cutting out the two lateral disks, and then the strips designed to form the pieces, A, A', A'', etc. Afterward we solder to the future outer extremity of each of the latter a small rectangle of the same width that forms a T with it. This done, we solder the two disks to the axle, leaving a space between them equal to the width of the pieces, A, A', A''. Then we solder the latter, one by one, between the two disks, so that they shall form equidistant radii; and finally we cut out six strips, curve them, and solder them successively to the bases of the radiating pieces. The drum is now finished. Were the external circle made in one piece, it could not be soldered accurately to each T, and there would be too many leakages or communications between the successive spaces separated by the radii. Such is the clock.

As regards the alarm, that may be considerably varied, but, in principle, it is always the cylinder, A, that, in descending, touches, at the desired hour, a detent which frees a weight that actuates the hammer of a gong or bell.

Fig. 3 shows an arrangement that might be adopted for

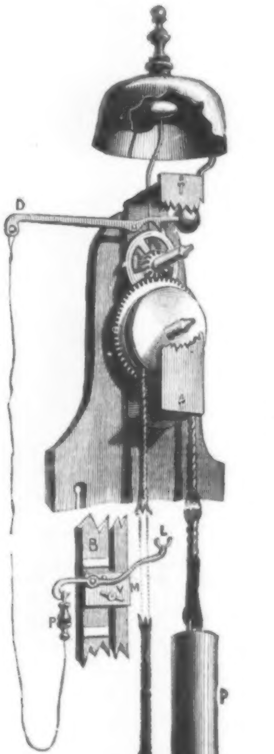


FIG. 3.—ARRANGEMENT OF THE ALARM.

the alarm. The axle of the drum, A, will here, on descending, abut against a lever, L, whose short arm carries a weight, P, which will be freed. In falling, P will depress the detent lever, D, which, in its preceding position, held a click immovable. This latter, being freed and no longer holding the lower mechanism, the large weight, P', will descend and actuate this mechanism and set the hammer of the bell in vibration. The detent mechanism, M, is fixed at the desired spot along the graduated rod, B, by means of a simple binding screw.

With the exception of the alarm, which would have to be made by a clockmaker, any tinsmith can easily construct the apparatus from the directions here given.

SIMABA CEDRON, A CURE FOR HYDROPHOBIA.

By GEORGE VAILLANT, M.D., Ph.D., New York City.

As there has been so much said and written about the incurability of hydrophobia, I should be much pleased if you would accord me some space to express my experience with a remedy for said disease.

Simaba cedron is the seed of a fruit of a small South American tree (Nat. ord. Simarubaceæ) somewhat resembling an almond tree. All parts of the tree are said to be impregnated with the bitter principle peculiar to the seed, but the latter is the only part used in medicine. The seed is about the size of a cashewnut, convex on one side, flat or slightly concave on the other; externally blackish and rough, hard and compact, but may be cut with a knife; internally a dingy yellow, with a metallic luster; when cut, inodorous and excessively bitter.

Chemical constituents: the seeds contain an intensely bitter, crystalline substance, soluble in boiling water, neutral to test-paper, named cedron.

In California and in the Southwest it is used by hunters and trappers as an antidote to the poison of crotalus and other venomous serpents, by binding shavings of the seed, moistened with whisky, upon the wound, and chewing a small portion. It seems to antidote all animal poisons, as it has been used in a number of cases of hydrophobia successfully, even after the spasms had become frightfully severe.

Three years ago I was called to attend a little boy named Charley Hoeffner, who, according to his mother's statement, was bitten by a mad dog three weeks previous to his taking sick. When I reached his bedside the boy was in fearful agony, howling and producing all sorts of indescribable sounds. After the minutest inquires and careful examinations, I diagnozed the case as genuine hydrophobia. Knowing I could not get this medicine (cedron) in any of the drug-stores near by, I hurried home and procured a small quantity of it (about a drachm—ʒ j) and used it hypodermically and per os. In less than twenty minutes after its administration, my patient became quiet, and, although watching him very closely for about five hours, there were no symptoms of recurrence of this dreadful malady. Visited him next day; found his mind clear and having recuperated from his nervous prostration. On the third day I examined him thoroughly, and to my utter astonishment I discovered a large sore, resembling a phagadenic ulcer, discharging a tenacious, dark-yellow pus of a very offensive odor.

I think this purulent secretion, which was possibly produced by cedron, saved the boy. The patient recovered after a week's treatment, and has not been ailing since.

Furthermore, I should like to state that I experimented with the pus secreted from the wound of the boy mentioned. I inoculated a tremendous big tom-cat with said pus, at 3 o'clock in the afternoon; he developed all the horrible symptoms of hydrophobia until he died in the terrific convulsions at 4:30 o'clock next morning, I having watched him very attentively, even to the risk of my own life.

Case 2. While I was rusticating at Saratoga, last summer, I was summoned, in consultation, to the bedside of a young lady, who was bitten by a pet dog five months previously. When I entered her room she was barking and snarling in the most vicious manner at those surrounding her. My diagnosis as true hydrophobia was indorsed by the other five physicians present during the consultation. I gave directions how to use "cedron" hypodermically, as it was utterly impossible to administer it per os. She recovered the same as my first patient.

It would be well for Mons. Pasteur and other scientific experimentalists to give this really wonderful remedy a fair trial, before inoculating any human being with the rabid virus.—*The Therapeutic Gazette.*

THE USE OF FLUORESCINE IN MAKING A SAFE LIGHT FOR THE PHOTOGRAPHIC DARK ROOM.

IN the British *Journal of Photography*, Mr. W. H. Harrison details a series of experiments on flourescine as follows:

Of late I have tried a long series of experiments with fluorescine, and find it to be of such use in relation to developing room illumination that I am likely to keep it always at hand for the future to aid in effecting that purpose. A sufficiently strong solution of it in albumen, to which one-fourth the volume of the latter of the strongest liquid ammonia has been added, has the power of giving films which cut the spectrum in half. When the solution contains just enough fluorescine to give a bright yellow film, all the rays above the yellow green are cut off when the initial light is not stronger than that of diffused daylight. Statements as to what rays a particular glass or other colored film cuts off have little meaning unless the intensity of the initial light used be also specified to some extent.

Fluorescine has another useful property. Being fluorescent to the blue and violet rays it lowers their refrangibility to green, and then transmits the yellow green so produced for use in the developing room. Thus it actually utilizes some of the actinic rays themselves, changing them so as to be of value in developing operations. At the same time, it cuts off none of the rays below the yellow green when the film is of the depth stated; consequently no better medium can be imagined for transmitting a very large amount of light, free from the blue green rays upward. After five months' experience and experiments with it, it has given me satisfaction in every respect.

By means of a strong single or double film of carminized albumen and a single film of fluorescine, a screen is made resembling in its optical properties the now celebrated "stained red" glass. The only difference is that the compound albumenized screen is the better of the two; it gives the clearer and brighter red with no orange. Stained red, when tested by a strong light, such as the direct light of the sun, passes a trace of orange.

Albumenized solutions of carmine and fluorescine mix without apparent decomposition, so probably their combined optical advantages may be obtained in a single film.

A strongish solution of fluorescine, having a good orange rather than a bright yellow color, cuts off almost all the green rays. A weak solution of fluorescine has a greenish and fluorescent appearance; it then transmits some of the blue rays unchanged, and lowers the refrangibility of the remainder. A substance is wanted which is fluorescent to the extreme violet, and transparent to other rays.

Weak and alkaline solutions of fluorescine have magnificent fluorescent properties, far in advance of sulphate of quinine and uranium glass. A very small weight of the crystallized dyes will usually go a very long way in preparing photographic lantern screens, and make the user independent of the manufacturers of colored glass.

Mr. Debenham has rung the death knell of pure red light in the developing room for ever, and has at last made a convert of the well known expert, Mr. J. Traill Taylor. The chief light of the future will be principally yellow when examined with the spectroscope—although to the eye it may not be always such, as in Mr. Debenham's light modified with glass of a feeble green tint. His green glass is of little use in promoting safety; it cuts off some of the red of the spectrum, and thereby so modifies the rest of the light that the observer hardly knows what color to call the available illumination, so constantly is the human eye the victim of optical illusions and delusions.

From its practical properties fluorescine is usually catalogued with the aniline dyes; but in chemical composition such may not be altogether its proper place. It may also be used to form films when it is dissolved either in collodion or varnish rendered strongly alkaline, by adding some ammoniacal gas dissolved in strong alcohol; but the solution in albumen is the best for present purposes. In collodion, after a certain strength in fluorescine is passed the film becomes opalescent. When too much ammonia in alcohol is added to varnish, some of the resin is precipitated and not redissolved. Unless there be a strong proportion of ammonia in the liquid, the color imparted to the film by the fluorescine is less intense, so more dye has to be added to produce an equal effect. Another way of increasing the intensity of a film thrown down from a liquid weak in ammonia is to subject the dried film for some hours to the action of ammoniacal gas. The best plan, however, is to dissolve the fluorescine at the outset in albumen and ammonia, as already stated; in this liquid it dissolves freely and immediately to apparently almost any extent. As to the keeping qualities of the solution, mine is two months old and as good as at first. Two or three weeks after mixing it exhibited symptoms of gelatinizing, so it was diluted with a little ammonia and water, which restored it to its original condition.

What is known as "true canary medium" owes its safety to its thickness—to its translucency and not to its color, for it transmits blue of low intensity. Herein the use of separating the safety of color from the safety of translucency is seen, because if the same make of white paper as used in canary medium be purchased and then stained with fluorescine to the same depth of yellow as the canary medium in the market, a paper apparently the same can be produced, yet which will allow the passage of safer and stronger transmitted light.

I have only recently commenced experiments on the values of different increments of translucency. The first step taken was to deal with the color element to get it under control, and to become independent of the meager and variable supply of colored glasses in the market. Fluorescine at one blow cuts off the most mischievous of the rays which fog photographic plates, yet is fortunately perfectly transparent to all the rest, in which it gives no trace of an absorption band. The yellow green can next be cut off when desired by a stronger solution of fluorescine aided by a little carmine, a safe and bright apparent orange being the result; in it, however, the red rays are present. When it is desired to specially absorb the yellow and orange rays, alkaline solution of litmus will do; but as yet I have not tried to make transparent litmus films. With any pure color of the lower end of the spectrum obtainable at will, the color element will be under complete control for experimental purposes, and the hues brighter than those of stained glass.

The optical properties of a sheet of glass coated with fluorescine and albumen are interesting when the sheet is used as a screen through which to observe a landscape. As it completely cuts off all the rays which are blue, or nearly blue, but permits the rest to pass freely, the general colors of the landscape and all but blue flowers are much the same as before, but the whole scene is greatly heightened in warmth and brilliancy. The leaves have the bright green hues of early spring; the dull leaden clouds covering the whole sky appear as though the sunshine were about to break through them. Yellow glass has the same effect in a degree, but those specimens of yellow glass in my possession exhibit it inferiorly, because their colors are not so pure and bright as that of the albumenized fluorescine. The sight also reveals what a large amount of blue is reflected by the leaves of trees, their apparent darkness at this season being changed to the brightness of youth by cutting off the cold blue element. The electric light is commonly said to have a ghastly effect; this is due to its containing more blue in proportion than does daylight. We do not call daylight ghastly, because we are accustomed to it and its normal proportion of blue; but, after gazing at a landscape for a few minutes through a film of albumen and fluorescine, the same landscape appears ghastly when viewed by ordinary daylight, especially when there is no direct sunshine. If a window were formed wholly of such films, the illusion would be strong enough to make unwary observers believe on a rainy day that the weather is fast clearing up, whereas in reality it is as bad as ever.

A photographer who cannot spectroscopically test the light of his developing room, or of any new screen he purchases for its window or lantern, is in a very helpless position in the matter of getting the best light for working. A spectroscope is not, however, necessary for the purpose. Dr. Van Monckhoven once pointed out a simple way of testing colored glasses and screens. He took a large sheet of cardboard, thick enough to be opaque to light. In this he cut a narrow slit, then laid upon the cardboard a piece of the glass to be tested. The glass but half covers the open slit, so that when a white light, such as that of a paraffine lamp, is placed on the other side of the cardboard it shines through the upper part of the slit freely. The illuminated slit is then viewed through a prism, at a distance of a yard or more. A common prism will do from a chimney piece ornament. A prism of optical glass is not necessary; one worth a penny or twopence is all that is required. Through the prism the operator will see the upper part of the slit giving the spectrum of white light, and the lower part of the slit giving the spectrum of the light after its passage through the glass under examination. He will thus by comparison see at once whether all the blue and violet are cut off by the glass. It is more comfortable to make observations of this kind with the room in total darkness, with the exception of the light coming through the slit. This is easily managed by using the above arrangement as one of the windows of a dark lantern. A way to test a colored window is to temporarily fix a sheet of tin foil on it with glycerine. The tin foil should have a slit cut in it. The operator then places a paraffine flame close behind the slit, and after dark examines with a prism from outside the window the light passing through the slit.

As the film of albumen on glass is excessively thin, the solution of fluorescine must be strong enough to look nearly as dark as ink. It is useless to attempt to get a thicker film of albumen by horizontal drying, for directly the film has any appreciable thickness it cracks as the water evaporates. These films should be varnished with a benzol varnish; alcohol dissolves the color.

COMPOSITION OF THE ASH OF STRAWBERRIES.

By JOHN M. H. MUNRO, D.Sc., F.C.S.

DURING last summer I took an opportunity of determining the composition of the ash of a sample of ripe strawberries, grown in the field by a Kentish fruit grower; 256 grms. of the ripe fruit, deprived of the stalks, yielded on prolonged drying at 100° 27·38 grms. dry matter, which, after careful incineration, left 1·10 grms. ash. The strawberries therefore contained:

Water	89·30
Organic matter	10·27
Ash	0·43
	100·00

The composition of the ash was as follows:

Sand and insoluble matter	6·61	
Phosphate of lime	23·91	containing 11·70 P_2O_5.
" " magnesia	trace	
Carbonate of potash	60·77	containing 41·40 K_2O.
Magnesia	2·93	
Soda	1·29	
Sulphuric acid (SO_3)	3·88	
Undetermined	0·61	
	100·00	

It seems evident from the above figures that in the straw

berry the whole of the potash exists in combination with organic acid, and the whole of the phosphoric acid as phosphate of lime. The quantity of potash present is very considerable, even when compared with that contained in the grape. I am informed by strawberry growers that when the plants forced in pots are grown with the aid of guano or very rich soil, it is generally found that although many blossoms are produced, they do not all set, or if they do the fruit is inferior in size and quality to the smaller quantity produced by less vigorous plants grown in poorer soil. The stronger and more highly forced plants are also found to be more liable to mildew.

Considering the benefit often derived by the vine from applications of potash manures, it seems at least possible that a special manure containing a fair proportion of potash would produce good results with strawberries grown in pots and with other fruits forced under similar circumstances. The experiment may have been tried here and there, but not, so far as I can learn, by growers of fruit for the market.—*Chem. News.*

TABLE OF THE SOLUBILITY OF CHEMICALS IN WATER.*

ABBREVIATIONS: s., soluble; ins., insoluble; sp., sparingly; v., very; alm., almost; dec., decomposed.

CHEMICALS.	WATER.	
	59° F.	212° F.
One part is soluble in:	Parts.	Parts.
Acid, Citric	0 75	0·05
Formic	v. s.	v. s.
Gallic	100	3
Oxalic	8	1
Pyrogallic	3·5	v. s.
Tannic	6	v. s.
Alum	10 5	ins.
Chrome	10	dec.
Ammonia, Nitrate	0·5	v. s.
Chloride	3	alm. ins.
Carbonate	4	dec.
Sulphocyanide	v. s.	v. s.
Ammonium, Bromide	1·5	0·7
Iodide (white)	1	0·5
Baryta, Nitrate	8	3
Cadmium, Bromide	v. s.	v. s.
Iodide	v. s.	v. s.
Copper, Acetate	15	5
Sulphate	2·6	0·5
Gold, Chloride	v. s.	v. s.
Gold and Sodium, Chloride	v. s.	v. s.
Iron, Chloride	v. s.	v. s.
Phosphate	v. s.	v. s.
Pyrophosphate	v. s.	v. s.
Sulphate	1·8	0·3
And Ammonia Sulphate	3	0·8
Iodide	v. s.	v. s.
Iodine	7,000	
Kaolin	ins.	ins.
Lead, Acetate	1·8	0·5
Chloride	ins.	33
Nitrate	2	0·8
Lime, Bromide	0·7	v. s.
Chloride	1·5	v. s.
Lithium, Bromide	v. s.	v. s.
Iodide	v. s.	v. s.
Magnesia, Nitrate	v. s.	v. s.
Mercury, Bichloride	16	2
Cyanide	12·8	3
Potassium, Acetate	0·4	v. s.
Bicarbonate	3·2	dec.
Bichromate	10	1·5
Bromide	1·6	1
Carbonate	1	0·7
Cyanide	2	1
Ferricyanide	3·8	2
Ferridcyanide	4	2
Ferrocyanide	4	2
Nitrate	4	0·4
Iodide	0·8	0·5
Oxalate	v. s.	v. s.
Permanganate	20	3
Sulphate	9	4
Sulphite	4	5
Sulphuret	2	1
Silver, Nitrate	0·8	0·1
Oxide	v. sp.	v. sp.
Sodium, Acetate	3	1
Bromide	1·2	0·5
Bicarbonate	12	dec.
Carbonate	1·6	0·25
Citrate	v. s.	v. s.
Granulated	v. s.	v. s.
Hyposulphate	1·5	0·5
Hyposulphite	1	0·12
Iodide	0·6	0·3
Nitrate	1·3	0·6
Phosphate	6	2
Pyrophosphate	12	1·1
Sulphite	4	0·9
Sulphate	2·8	0·4
Tungstate	4·0	2·0
Strontia, Chloride	1·88	v. s.
Uranium, Nitrate	v. s.	v. s.
Chloride	v. s.	v. s.
Persulphate	v. s.	v. s.
Zinc, Iodide	v. s.	v. s.
Bromide	v. s.	v. s.
Chloride	0·33	....

PHOSPHO-CITRIC ACID.

A PREPARATION TO SUPERSEDE CITRIC AND TARTARIC ACIDS IN MINERAL WATERS.

By J. NAPIER, F.C.S.

CITRIC and tartaric acids have long been used for acidulating or giving to mineral waters their acid flavoring, but these acids have certain disadvantages, inasmuch as their solutions cannot be kept for any great length of time without the formation of a fungoid growth, and also the extreme difficulty of obtaining them free from lead.

A solution has recently been offered to the trade, called phospho-citric acid, intended to supersede citric and tartaric acids in mineral waters, a sample of which I have lately received, the composition of which, I have no doubt, will interest analysts. It contains:

	Per cent.
Free phosphoric acid	34·34
Phosphate of magnesia	1·86
Sulphate of magnesia	1·93
Sulphate of lime	0·55
Iron and alumina	traces
Citric acid	6·50
Water	54·82
	100 00

Poisonous metals were entirely absent, and so also were free sulphuric, hydrochloric, nitric, and acetic acids. The solution was comparatively clear and almost colorless. According to the proportions instructed to be used, the quantity of phosphoric acid in a small bottle (half pint) will amount to 0·95 grain, which I found to be the case in a sample of lemonade made with the above. The flavor and appearance were quite as good as that made with the organic acid.

Seeing that phosphoric acid has been largely used and appears to be highly valued for raising bread and pastry, and that it is recognized as an important medicinal constituent to the system, there is no reason why this article should not be used in this highly diluted form as the acid flavoring of lemonade and other mineral waters.—*The Analyst.*

TESTING THE CARBONIC ACID AND ILLUMINATING HYDROCARBONS IN COAL GAS.

AT the meeting of the Societe Technique in 1882, M. Chevalet introduced to the notice of the members the Orsat apparatus for testing the presence of carbonic acid and carbonic oxide in coal gas. This apparatus he has since found to possess the very great inconvenience of requiring extremely careful manipulation. It is likewise very fragile; and if there should be the slightest escape from one of the taps or joints, it does not give correct indications. It is, in fact, an instrument which can only be intrusted to hands accustomed to performing chemical operations. The apparatus designed by M. Chevalet, which is shown in the annexed engraving (Fig. 1), is, on the contrary, very simple in character, and may be employed alike for testing for carbonic acid and sulphureted hydrogen. It consists of a test-tube, A, mounted upon a stand, and furnished at its lower part with a tap, B. Inside the test-tube there is a small stick of caustic potash, C, of known volume; and the top of the tube is hermetically closed by a cork, through which passes a bent tube, connected with a graduated tube, D, the extremity of which dips into a glass vessel, E, containing colored water.

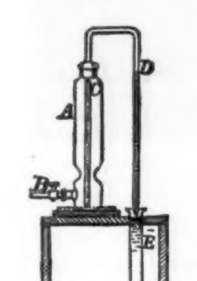


FIG. 1.

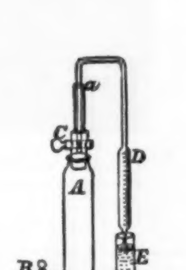


FIG. 2.

The testing operation is performed as follows: The tap, B, is connected by means of an India-rubber tube with the gas supply; and a stream of gas is allowed to flow into the tube until the whole of the air has been displaced. Then the tap is gently turned off, and the operator awaits the result. If the gas contains carbonic acid, the water in the vessel, E, is at once seen to rise in the graduated tube. The vessel should then be raised so that the water it contains is at about the same level as that in the graduated tube. (This can easily be effected by a pinion by which it is supported.) If at the expiration of 15 to 20 minutes the water remains stationary in the graduated tube, the absorption has been complete. The water-levels should then be carefully adjusted, and the quantity of liquid contained in the graduated tube read off. Supposing that this tube is so divided that each large division represents the 100th part of the entire capacity of the test and other tubes, each division occupied by the water will represent the quantity of carbonic acid absorbed; and if these large divisions are subdivided into ten equal parts, the operator is able to ascertain the 1000ths of carbonic acid contained in the volume of gas under experiment. In order that the operation may be correct, the temperature should remain constant during the experiment. The hands of the operator should not be placed upon the test-tube; nor should there be any source of heat near. Further, the tap and cork must both be absolutely sound; otherwise air will make its way into the test-tube while the water is rising in the tube, D.

With this apparatus the gas may be tested before passing into the purifiers; and again on its exit therefrom. The difference will show the volume of sulphureted hydrogen gas absorbed by these vessels. When this test is being made, it is advisable to have two apparatus; and to operate simultaneously upon the gas both before and after it has undergone purification. If there should be any error, it is the same in each case. The following are some results obtained in gas-works where the purifying material employed was oxide of iron only:

Before the purifiers....2·45 per cent. of absorbable gases.
After " " ...2·25 " " "

These trials showed that oxide of iron absorbs very little gas. The same gas tested by an Orsat apparatus did not show more than 2 per cent. of carbonic acid. M. Chevalet's apparatus is therefore more sensitive than the other; and this sensitiveness is accounted for by the construction of the instrument. By its aid the quantity of sulphureted hydrogen absorbed by the purifiers may be readily found; and, as a consequence, managers are enabled to ascertain whether one coal produces more of this impurity than another. They may also ascertain the quantity of carbonic acid left in the gas after purification by lime, and consequently whether the lime is doing its work properly.

This apparatus above described is capable of modification so as to be used for testing the quantity of illuminating hydrocarbons present in coal gas. For this purpose it is arranged as shown in Fig. 2, in which A is the test-tube, furnished with two glass taps, B, C, ground so as to fit perfectly. This is necessary because the reagent (bromine) used in the test acts upon cork, India-rubber, and copper, all of which are used in the other apparatus. When a test is to be made, an India-rubber tube is fitted on to the lower tap, then both taps are opened, and the gas to be tested is passed into the tube, A, as before. As soon as all the atmospheric air has been expelled, and the test-tube is full of gas, the two taps should be closed (the lower one first). Into the tube rising from the top of the upper tap 0·5 c. c. of bromine, and afterward sufficient water to make up a total of 5 c. c., are run by means of a pipette; this volume being indicated by a line marked upon the tube, as shown at *a*. The orifice of the tube is then closed with the finger, the tap turned, and the mixture of bromine and water allowed to run into the test-tube. When it has all passed down, the tap is closed and the test-tube well shaken, so as to cause a thorough admixture of its contents. The following reaction then takes place: The bromine attacks the illuminating hydrocarbons (such as olefiant gas, propylene, and butylene), while it leaves untouched the marsh gas, hydrogen, and carbonic oxide. After several shakings the test-tube is again placed upon the table, and 5 c. c. of a concentrated solution of potash are passed into the mixture, in the same way as before. The tube is once more shaken until the yellow-red vapors of the bromine have completely disappeared.

The test tube is then again placed upon the table, and into the neck of the upper tap is inserted a bent pipe ending in a pipette divided into cubic centimeters (or better still into half cubic centimeters). The lower portion being plunged into the glass vessel, E, containing colored water, the upper tap is opened, and the water is immediately seen to rise in the pipette. The water levels are then adjusted as in the former experiment, and the contents of the pipette are read off. Supposing it to be 13 c. c. this is noted, and to it are added the 5 c. c. of bromine and water and the 5 c. c. of potash, previously introduced; making a total number of 23 c. c. Then dividing this figure by the number of cubic centimeters found by gauging the test tube, the quotient multiplied by 100 will give the percentage of the gas absorbed by the bromine and potash. Subtracting from this number the carbonic acid found in a preliminary test by the employment of potash alone upon the gas under examination, the quantity of illuminating hydrocarbons absorbed by the bromine is ascertained.

If a number of successive tests are made, and the operation has been well performed without loss of gas in manipulation, the results are found to differ very little indeed—scarcely to the extent of 0·002 per cent. The process is therefore highly sensitive; is correct in its indications; and, above all, is easily manipulated, inasmuch as it does not necessitate the use of a water or mercury vessel, or instruments of precision for measuring the volume of gas under examination. One essential precaution must, however, be taken in all the testings, viz., to work by diffused light, far from all source of heat, and as much as possible in a laboratory facing the north. This situation is especially recommended because the laboratory would then be free from the rays of the sun, which if admitted would cause the gas in the test tube to expand, and thereby vitiate the experiment. With purified gas made from the coal of the Pas de Calais, M. Chevalet obtained the following results:

Illuminating Hydrocarbons. Per cent.	Illuminating Power. Liters.	Carcel.
5·10	=105·0	=1·00
5·45	=105·0	=1·00
5·97	=100·2	=0·95
6·08	= 99·4	=0·94
6·51	= 95·9	=0·91
5·17	=105·2	=1·00

M. Chevalet intends repeating these experiments, using gas made from different coals, in order to see whether there is a constant relation between the illuminating power and the quantity of light-giving hydrocarbons contained in the gas. —*Journal of Gas Lighting.*

PREHISTORIC REMAINS.

A LARGE Indian mound near the town of Gastersville has recently been opened and examined by a committee of scientists sent out from the Smithsonian Institution. At some depth from the surface a kind of vault was found in which was discovered the skeleton of a giant measuring 7 feet 2 inches. His hair was coarse and jet black, and hung to the waist, the brow being ornamented with a copper crown. The skeleton is remarkably well preserved. Near it were also found the bodies of several children of various sizes, the remains being covered with beads made of stone of some kind. Upon removing these the bodies were seen to be inclosed in a network of straw or reeds, and beneath this was a covering of the skin of some animal. On the stones which covered the vault were carved inscriptions, and these, when deciphered, will doubtless lift the veil that now shrouds the history of a race of giants that at one time undoubtedly inhabited the American continent. The relics have been carefully packed, and forwarded to the Smithsonian Institution, and they are said to be the most interesting collection ever found in the United States. The explorers are now at work on another mound in Bartow County, Pennsylvania.

A PLAGIARISM.

To the Editor of the Scientific American:

I take the liberty of calling your attention to a plagiarism that appears in SCIENTIFIC AMERICAN SUPPLEMENT of November 22, 1884. The first three paragraphs of the article "Chemistry," by William H. Taggart, D.D.S., may be found in the introduction to Eliot and Storer's Chemistry, abridged by W. R. Nichols. R. S. H.

[The article above alluded to was an abstract from an "original" paper read by Dr. Taggart before the Illinois State Dental Society, 1884.—EDS. S. A.]

* Furnished to the Society of Amateur Photographers of New York by Dr. John H. Janeway, U. S. A., Nov. 11, 1884.

THE REFORMATION IN TIME-KEEPING.

By W. F. ALLEN.

ON November 19, 1883, the daily papers of the United States and Canada, from the Atlantic Ocean to the Rocky Mountains, contained more or less elaborate accounts of the change from local to "standard time" which had been made on the previous day. Comparatively few among the millions of people who read these accounts took the trouble to investigate the actual meaning of the change or the arguments in its favor. It appeared to be the work of practical railway managers, and to be favored by leading scientists. Watch-makers agreed to and aided the change, and few other persons were apparently interested. So the people quietly acquiesced, reset their watches a few minutes faster or slower, and for the most part soon forgot that any but "standard time" had ever been in use.

In the present generation we have become so accustomed to the use of accurate time and the ready means of obtaining it, that we hardly realize how dependent we are upon it. Were it possible to suddenly destroy all clocks and watches in any given center of population among civilized nations, while all other surroundings of modern development remained as before, we can scarcely conceive of the endless confusion that would arise. Only by contemplating the results of such a catastrophe can we fully understand what an important part the knowledge of accurate time plays in our every-day affairs.

Man shares with the inferior animals the knowledge and the use of the simplest and earliest division of time into day and night, and in a more restricted sense into seasons. The division of the day into minor parts has been developed by man as necessity or convenience required. It has not been many years since watches were made with hour-hands only, and the general use of the finer divisions into minutes and seconds is almost entirely the outgrowth of the requirements of modern civilization. Astronomical time-keeping is not here considered. By the Babylonian system of dividing the day, which was used by the Jews and other Oriental nations, the time between sunrise and sunset was portioned into twelve equal parts at all seasons of the year, the hour varying in length with the season. If this method of division still prevailed, the hours in New York city would vary in length from about forty-six to about seventy-five of our present minutes. In the Arctic regions the inapplicability of this system to general use would reach its climax of absurdity.

The general facts upon which all systems of time-keeping are based are commonly understood, but the details are seldom referred to.

The most primitive kind of timepiece is a sun-dial. Reduced to its simplest form, a sun-dial consists of a straight pole erected upon a permanently fixed circular plate, the shadow of the pole indicating midday when it coincides with a line drawn due north from the base of the pole, the pole being erected upon a line parallel with the axis of the earth. The other hours of the day are indicated by marks upon the circular plate upon which the shadow of the pole successively falls.

When the sun-dial was invented cannot be stated. It was of very ancient origin, and is mentioned in the thirty-eighth chapter of Isaiah. The clepsydra, or water clock, and the hour-glass, although very ancient, must from their nature have been invented subsequent to the sun-dial. But sun-dials, of which there are about a dozen different kinds, although common, were never in such general use as clocks are in modern times, and were philosophical rather than popular instruments. The clock was invented about 1379, and the pendulum as a regulating power in 1657.

The rapid development of the science of horology in the present century has been almost coincident with and in no small degree dependent upon the construction and operation of railway and telegraph lines. The needs of these great engines of modern civilization created a general demand for exactness in time reckoning which had never existed before. It was required both for the use of their employes and for the public which patronized their lines.

A sun-dial being stationary, when properly made and adjusted exhibited solar time correctly, and a watch regulated from the dial by the equation of time would also be correct for that particular spot; but the moment the owner of the watch began to move east or west his time-piece no longer registered correct time, and when he traveled with the speed of a railway-train the error was rapidly exaggerated.

The necessity for exactness before mentioned, and the impossibility of adhering to local time, early attracted the attention of railway managers, and caused them much perplexity and annoyance. With the rapid construction of railway lines, the commingling of the various local standards soon became decidedly intricate. Travelers were greatly inconvenienced by the lack of knowledge of the standard upon which the time of trains as advertised was based, and to such the situation was full of difficulties. Some of these difficulties were stated in an "open letter" published in *The Century* for September, 1883. The subject in its practical aspect also attracted the attention of scientists and scientific societies. It became a prominent topic of discussion at meetings of the American Metrological Society, the Association for the Advancement of Science, and the Society of Civil Engineers. Although astronomers use sidereal time, based upon the position of the stars, and not of the sun, in common with many other scientists they were generally warmly interested in the subject.

The local time kept by clocks is an average of solar time, and is properly designated "mean time," as distinguished from the variable time shown by the sun-dial. No clock or watch can be made to keep the time as shown by the sun-dial, and this new system of time-keeping, therefore, became necessary when clocks and watches were invented. The relation between mean and apparent time, and what is meant by "the equation of time," may be seen at a glance by reference to the accompanying diagram. Mean time being represented by the right line graduated for the several months of the year, the variation of apparent time is shown by the curved line entwined around it. In other words, a line drawn through the several positions of the sun at mean noon will describe the curves as indicated. For reasons which need not here be stated, the diagram will be found generally correct for one year only out of four; but, upon the scale by which the diagram is drawn, this error is infinitesimal. It is hardly necessary to state that the principal cause of the variation between mean and apparent time is "the obliquity of the ecliptic to the equinoctial."

Apparent time is about fifteen minutes slower than mean time about February 10, and about sixteen minutes faster on October 27. They agree about April 15, June 15, August 31, and December 24. If a well-regulated clock were set by apparent time on October 27th, it would be about thirty-one minutes faster than apparent time on the following February 10. It will be seen that, under such circumstances, clock time would vary as much from true sun time as any clock set by the present system of standard time varies from mean time at the most extreme point.

The safe operation of a railway requires that the watches of all its employes upon, or who have occasion to refer to, the same trains should always indicate the same moment of

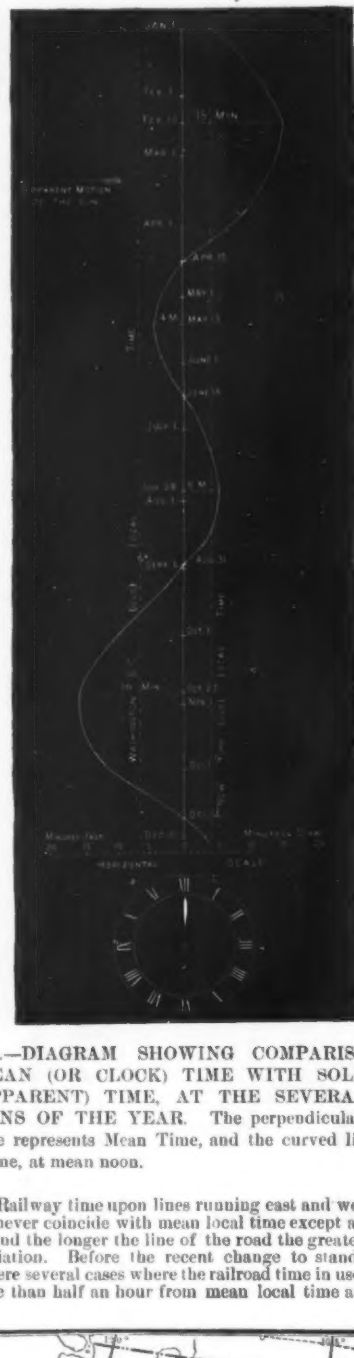


FIG. 1.—DIAGRAM SHOWING COMPARISON OF MEAN (OR CLOCK) TIME WITH SOLAR (OR APPARENT) TIME, AT THE SEVERAL SEASONS OF THE YEAR. The perpendicular central line represents Mean Time, and the curved line Solar Time, at mean noon.

time. Railway time upon lines running east and west can of course never coincide with mean local time except at a single point, and the longer the line of the road the greater will be the variation. Before the recent change to standard time there were several cases where the railroad time in use differed by more than half an hour from mean local time at various points. The inhabitants of the surrounding country at such points, having no standard of reference except the railway clocks, accustomed themselves to and used railway time without inconvenience, and in a number of instances, where the railway standard was changed from some cause, the people made the same change in their time-pieces. It was important in connection with railway-trains to keep exact time, and for all other purposes any relative time was sufficiently accurate.

In the early part of the year 1883 there were fifty-three standards of time in use on the railroads and by the people of the United States and Canada. These standards governed sections with no definite limits and upon railroad lines were apparently inextricably mixed and interwoven. The condition of the matter was abnormal in numerous instances, there being no less than three hundred points where railroads, using different standards of time, crossed each other and exchanged traffic. At almost every city of importance several standards were used by the railways, and in some cases the city time differed from any of them. Local jealousies made the chance of effecting reform apparently hopeless. Many who warmly favored standard time regarded the reform as one unlikely to be soon accomplished.

The solution of the problem necessarily required a close and long-continued study of the peculiarities of the situation. Whatever change was proposed must affect as little as possible the relations which previously existed between railway lines and business communities.

A complete system of standard time was finally devised and submitted in April, 1883, to several railway conventions, assembled to consider other subjects, at which about fifty important companies were represented. The system proposed was deemed practicable, and recommended for adoption, by the railway officials present at these conventions. It involved the total abolition of the use of local time by the public, except at points situated on the governing meridians.

A theory of reform had been under consideration by scientific societies for years, and several systems of standard time had been proposed, founded upon this theory, without practical result. Many investigators of the problem among railway officials and scientists had independently arrived at the conclusion that this theory was the correct one. It was based upon the idea of grouping sections of the country together under the same standard with an even-hour difference between the standards of the adjoining groups. "Eastern standard time," which is the standard of the section in which Boston, New York city, Philadelphia, Washington, etc., are located, is simply the mean time of the seventy-fifth meridian west from Greenwich, and the time kept in all these cities is now precisely alike. The dotted lines on the right and left of the diagram represent the mean times formerly kept at New York city and Washington in their relation to "Eastern" standard time. If a curved line were projected on one of these dotted lines parallel with the curved line on the diagram, and at the same distance, its relation to the central perpendicular line would represent the relation which solar time at New York or Washington bears to the standard time of the seventy-fifth meridian.

In the various discussions of the question a difficulty arose in deciding upon the best governing meridian. Should it be Greenwich, Washington, or New York? Each had its advocates. If this question could be settled, a more serious one arose in determining the proper lines upon which the sections could be divided. The result of its adoption has proved that the system proposed in April, 1883, solved these questions satisfactorily. This system is now in force, and is represented in outline on the map which appears on this page. It will be noticed that the dividing lines are irregular. Communities near the border which have adopted the system, use the standard east or west of their locations, according to the direction in which their business interests lie. In other words, the question is determined by convenience of use, as questions in regard to time-keeping have always been determined. The peculiarities of ownership or operation of the railroads determine their points of change. Legislative enactment will doubtless ultimately define the precise boundaries of the sections of countries to be governed by each standard.

The action of the railroad companies having been assured, the subsequent action on the part of city governments became possible, as it could not have been otherwise. Of the labor and means employed to secure this action on the part of the railways and the cities it is unnecessary here to speak. They proved sufficient to accomplish very fully the end desired. More than eighty per cent. of all the cities of over ten thousand inhabitants in the United States have adopted standard time.

The adoption of the new standard required a simultaneous change to be made in the railway-clocks and the watches of employes upon nearly every railroad in the United States and Canada, the change varying from one minute and three seconds on the Pennsylvania Railroad to forty-five minutes on the Intercolonial Railway of Canada. The exceptions were two roads in the vicinity of New Orleans, and a few lines in the vicinity of Denver. The change was also slight for some of the St. Louis roads. The Intercolonial Railway adopted the time of the seventy-fifth meridian as a matter of convenience, instead of that of the sixtieth meridian, to which its location would have properly assigned it. So perfect were the preparations that not a single accident at any point is

recorded as having been caused by the change. On the day when the new standards took effect, the clocks of about twenty thousand railway-stations and the watches of three hundred thousand railway employes were reset. Hundreds, perhaps thousands, of city and town clocks were altered to conform. How many individuals reset their watches it is impossible to compute, but they could certainly be reckoned by millions. Probably no such singular incident has ever before happened, or is likely to occur again.

At the present time, from the Atlantic Ocean at the eastern extremity of New Brunswick, to the Pacific coast at Oregon, the minute-hands of the railway clocks and watches indicate the same minute of time at all hours, and fully fifty million people regulate their business affairs by standard time.

While a few and for the most part unimportant communities, and some railway companies, did not make the change immediately, so large a majority adopted the system on November 18, 1883, that that date may be fairly taken as the one upon which the reform took effect. Several New England railroads, the Central Vermont Railroad being the most important, commenced to run their trains by "Eastern" standard time on October 7, 1883. The Central and Southern Pacific Railroads west of Ogden and Deming, and their branch lines, are the only railroads in the United States or Canada which do not now use standard time, if we except two purely local roads in Pennsylvania, aggregating less than twenty miles in length. The last to adopt the system were the Union Pacific Railway and the city of Omaha, on May 1, 1884.

The legality of the use of standard time was established by the decision of Judge Holmes, of Massachusetts, that whatever time was in ordinary use by the people of any community was lawful time; and his decision is not likely to be reversed. From an economic standpoint it is difficult to perceive what difference it makes to a laboring-man whether he commences work at a time nominally called seven o'clock or half-past seven, so long as he receives full wages for a full day's work.

Some of the objections raised to the use of standard time as a substitute for local time are as amusing as the famous declaration of the Rev. John Jasper, of Richmond, Virginia. It is urged that the sun was divinely set to rule the day, and therefore to use any but solar time is akin to, if not actually, immoral conduct. As the moon was also set to rule the night, such persons, if logical, should obey that portion of the divine command also. The fact is that solar time was necessarily abandoned when clocks came into general use, and time based upon one or another arbitrary standard has governed the civilized world ever since. The present system, with its widely extended uniformity, simply conforms to the principle of securing the greatest good to the greatest number, a principle which must everywhere in the end prevail.—*Popular Science Monthly.*

PHENOMENA ATTENDING MIXTURE.

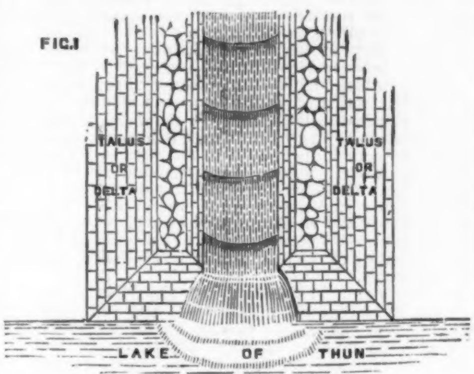
AT the last meeting of the Physical Society, Professor F. Guthrie read a paper "On Certain Phenomena Attending Mixture." In a previous paper Dr. Guthrie had noticed the increase of volume attending the separation of triethylamine and water effected by heat. The present paper is an account of a more thorough examination of this and allied phenomena. Experiments conducted with a number of different liquids showed that mixtures can be arranged in two distinct classes. Of the first, a mixture of water and ether is an example; when shaken up together they mix, heat is evolved, and a diminution of bulk takes place. If any excess of ether present is poured off, and the lower clear liquid heated in a sealed tube, it becomes turbid owing to the separation of the ether. This is accompanied by an increase of bulk and absorption of heat. Triethylamine and water and diethylamine and water are mixtures belonging to this class; the temperature of separation is a function of the ratio in which the two liquids are present. A typical case of the second class is a mixture of alcohol and bisulphide of carbon. These mix with one another in all proportions above 0 deg. Cent. with increase of bulk and absorption of heat. Upon being cooled to about 17 deg. Cent. they separate. The separation of a mixture of ether and water and of a mixture of alcohol and the bisulphide was shown. In these cases the action is regarded as a chemical one, and generally an excess of one liquid or the other is present. To determine the combining proportions two methods were used. In the first a number of mixtures of the same two liquids in different proportions were taken, and the rise or fall of temperature produced by their mixture measured. When this was a maximum, there might be assumed to be no dead matter present. In the second method, which is more delicate but more laborious, and which was used when the approximate combining proportion had been formed by the first, the change of volume produced by mixture was noted; when this increment is a maximum, the liquids are present in their combining proportions. These experiments gave very concordant and definite results; for example, that the molecular compound of ether and carbonic sulphide is represented by the formula $C_4H_{10}O.2CS_2$; and that of chloroform and carbonic sulphide by $CHCl_3.CS_2$. A striking confirmation of this view is afforded by the behavior of the vapor tension of a mixture. The temperature being constant, if the vapor tension be plotted with the percentages of the more volatile liquid as abscissæ, the curve is for a mixture of two liquids which have no chemical action upon one another, as the iodide and bromide of ethyl, a straight line. For ordinary mixtures, however, this is not the case. A curve is obtained in which there is observable at a certain point an irregularity. The corresponding abscissa indicates the molecular combination found by the previous experiments.

VOLTAIC CONSTANTS.

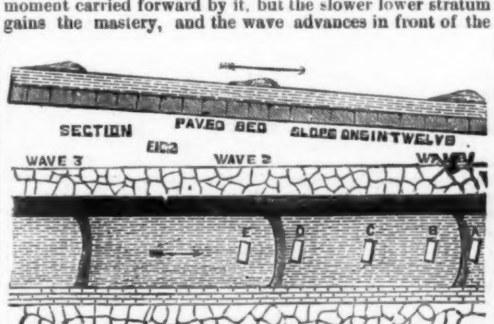
Dr. C. R. Alder Wright read a paper by himself and Mr. C. Thompson, on "Voltaic and Thermo-voltaic Constants." In a former paper the authors had stated that in a cell set up with two metals immersed in pure solutions of their corresponding salts, a given increment in the strength of the solution surrounding the metal acquiring the higher potential causes an increment (a) in the E.M.F. set up (e), while an increment in the strength of the other solution causes a decrement (b) in the E.M.F. This law is now substantiated. It is, however, found that for dilute acids instead of metallic salts b may be negative. The authors also find that it is possible to represent the E.M.F. of a cell by the difference of two quantities, which they term the voltaic constants. These are quantities, one relating to each plate and its surrounding liquid. The voltaic constant of a metal and a liquid is a function of the nature of the metal surface, the strength of the solution, and the temperature, but is independent of the opposed plate and its liquid. It is practically defined as the E.M.F. set up when opposed to a zinc plate in a solution of the corresponding zinc salt of the same molecular strength. The authors further conclude that the E.M.F. of a given combination usually stands in no simple relationship to the chemical action taking place in the cell, but that it may be expressed by the sum of the mechanical equivalent of the chemical action per electro-chemical equivalent, and the difference of two quantities, one being related to each metal and its surrounding liquid, and being constant for that metal and liquid, termed thermo-voltaic constants. This thermo-voltaic action may act with or against the chemical action in producing E.M.F. In some cases, as in that of a cell composed of iron in ferrous sulphate, and cadmium in cadmic sulphate solutions, the E.M.F. is against and greater than that produced by chemical action; consequently, the cell works backward with absorption of heat.

THE FLOW OF STREAMS.

THE following notes by Mr. George Maw, of Benthall Hall, have been sent to *Nature* by Mr. J. G. P. Smith, and will interest some of our readers: "As I know you have been making observations on river currents and the effect of friction on the motion and passage of streams, I send you the accompanying notes on a very curious case we met with near the Lake of Thun. It is an extreme illustration of the action of gravitation and friction working, as it were, in



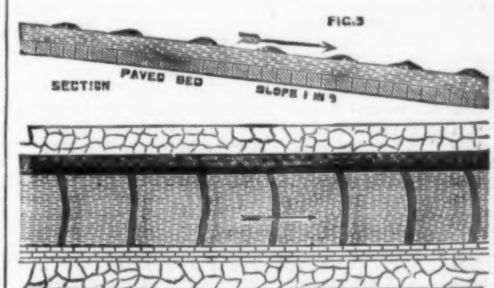
opposition. I have often observed something of the same kind before, but never so well marked. Looking up the stream from the lake, the effect was just like a long ladder of low waves approaching you, each separately breaking over a low fall into the lake. The intermittent flow of streams familiar to us, from the rapid pulsation of the cataract to the slower rise and fall at regular intervals of less precipitous streams, is strikingly illustrated in a mountain stream flowing into the Lake of Thun, near Merligen. The lower part of its course over a small talus or sloping delta has been artificially banked up as a straight channel 15 ft. wide, evenly paved and walled with stone. The lower part has an inclination of about 1 in 12, and the upper part toward the mountain gorge a slope of about 1 in 9. It flows directly in the lake, and, viewed from the lake, presents a remarkable appearance. The fall into the lake pulsates at intervals of three and a half seconds by a sudden increase of volume, and the stream above, flowing over the level paved bed, presents the appearance of a ladder of low advancing waves occurring at regular intervals of about 40 ft. over the lower slope of 1 in 12, and at less regular intervals of about 12 ft. over the steeper slope of in 1 in 9. Of the motion of the stream over the lower slope of 1 in 12, the following particulars were noticed: A floating body travels at the rate of 9½ ft. per second, but this does not represent the speed of any part of the water. The wave-heads advanced at the rate of 13 ft. a second, and the intervening stretches of stiller water—as nearly as I could judge—at about 6 ft. a second. It is evident that the upper and lower currents are traveling at different rates—the bottom current retarded by friction, the surface current advanced over it by gravitation, accumulating at intervals of about 40 ft. into wave heads of a semicircular form, the sides being bent back by latent* friction. The motion of a floating body in the stream of advancing waves is very peculiar. A piece of wood thrown in at A, just in front of the advancing wave, No. 1, is for a moment carried forward by it, but the slower lower stratum gains the mastery, and the wave advances in front of the



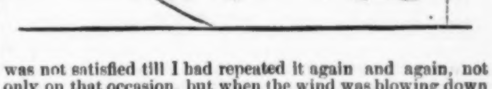
wood, which is successively found at B, C, D, E, etc., relatively to the advancing wave heads, the floating wood recedes up the stream, though actually advancing at a rate between that of the upper and under or ground current. The waves occur at intervals of about 40 ft., and occupy a trifle over three seconds in passing over the space that separates them. Of the motion of the stream over the steeper slope of about 1 in 9, the following particulars were noticed: A floating body travels at the rate of 12½ ft. per second. The wave heads were less clearly defined than on the less steep incline, and it was difficult to accurately measure their rate of advance, but as in the other case they rapidly overshot a floating piece of wood. They occur at much shorter intervals—about 12 ft.—than on the less steep incline."

Mr. Smith's observations, referred to by Mr. Maw, were made upon the current of the river Severn with a view to explain the cause why the men who navigate the barges, in descending this river by the force of the current only, are enabled to steer with a moderate degree of effectiveness. The power results from the different velocities of the current at and beneath the surface. A little below the surface—roughly speaking, at about one-fifth of the actual depth—the current seems to have its maximum velocity, and consequently the hull of the vessel floating down the stream is immersed in water flowing more rapidly than that at the surface, on which the rudder for the most part acts.

He says: "I was able to demonstrate this fact by the following simple experiment: Having noticed that leaves of trees, after lying for some time on the ground and nearly saturated with water, become almost of the same, and after a long time of greater, specific gravity than water, it occurred to me that such leaves, while in the first named stage, would show what I desired to know, namely, the relative velocities of the stream at different levels below its surface. Two straight bars of wood, each about 13 ft. or 14 ft. long, were tied together at one end; between the two the foot stalks of a number of poplar leaves were inserted—this kind was chosen because of the length of the foot stalk for insertion between the bars, and its brightness of color rendering it more visible in the depth of the water; the bars were charged with the leaves at intervals of about 3 in., and then, choosing a place where the river was of suitable depth, the bars charged with leaves were plunged into the water, the



connected ends touching the ground. The water was so clear that every leaf remained visible; then I opened the ends of the bars at the surface, and was gratified by seeing every leaf floating away, and preserving as to depth very nearly the same relative position. Floating with the stream in my boat, I soon saw those nearest the bottom gradually lagging behind, and still more was I gratified when, after proceeding about forty yards, the leaves that were about 2 ft. below the surface had distanced those at the surface in an unmistakable manner by at least 3 ft., the current being about 4 ft. per second, the whole series forming a curve, as is here shown. Greatly pleased with this first experiment, I



was not satisfied till I had repeated it again and again, not only on that occasion, but when the wind was blowing down the river, and therefore should have accelerated the leaf at the surface, which it undoubtedly did—but only the leaf on the surface, and that to a much smaller degree than I expected, and it left unaffected all that were beneath. A calm day is the best for this experiment, because the ripple renders it difficult to see below the surface. The water must, of course, be clear—a condition with which we are much favored in this river. Mr. Maw's observations of the different velocities of the pieces of wood and the wave heads are quite in harmony with mine; the depth of the water in the stream at Merligen would be only a few inches, and pieces of wood were immersed so deeply that they would be more affected by the retarded current four-fifths below than by that one-fifth at the surface."

* Lateral here is obviously intended.

NATURAL SCIENCE IN SCHOOLS.*

By Prof. HENRY E. ARMSTRONG.

HOWEVER fully it may be admitted by the few that it is important, nay, essential, that all members of the community, whatever their station or occupation, should during their school career receive some instruction in the elements of natural science, the general public have not as yet had brought home to them with sufficient clearness that, just as a knowledge of foreign languages is essential to all who are brought into intercourse with foreigners, so in like manner is a correct knowledge of the elements of natural science of direct practical value to all in their daily intercourse with nature, apart from the pleasure which such knowledge affords. In fact, judged from a purely utilitarian standpoint, the advantages to be derived from even the most elementary acquaintance with what may be termed the science of daily life are so manifold that, if once understood by the public, the claims of science to a place in the ordinary school course must meet with universal recognition. To quote Huxley: † "Knowledge of nature is the guide of practical conduct; . . . any one who tries to live upon the face of this earth without attention to the laws of nature will live there for but a very short time, most of which will be passed in exceeding discomfort; a peculiarity of natural laws, as distinguished from those of human enactment, being that they take effect without summons or prosecution. In fact, nobody could live for half a day unless he attended to some of the laws of nature; and thousands of us are dying daily, or living miserably, because men have not yet been sufficiently zealous to learn the code of nature."

But it is also and mainly on other and far higher grounds that we should advocate universal practical teaching of the elements of natural, and more particularly of so-called physical, science, viz., that it tends to develop a side of the hu-

* "On the Teaching of Natural Science as a Part of the Ordinary School Course, and on the Method of Teaching Chemistry in the Introductory Course in Science Classes, Schools, and Colleges." Paper read at the Educational Conference of the International Health Exhibition by Henry E. Armstrong, Ph.D., F.R.S., Sec.C.S., Professor of Chemistry in the Finsbury Technical College.

† This writer's "Introductory" to Macmillan's Science Primers, and his "Physiography: an Introduction to the Study of Nature," should be studied by all who wish to know what science is and how it should be taught.

man intellect which, I believe I am justified in saying, is left uncultivated even after the most careful mathematical and literary training—the faculty of observing and reasoning from observation and experiment. It is entirely from this latter point of view that I shall venture to propound a scheme for teaching the elements of that branch of physical science with which I am most intimately acquainted.

This exhibition affords some few noteworthy illustrations of the way in which the importance of teaching the elements of natural science has received practical recognition in our schools. Thus we have indications of the work being done by the Birmingham School Board; the London School Board call attention to their system of training pupil-teachers in science; Mr. Robins shows plans of one of the best, if not the best, equipped school chemical laboratories—that of the Manchester Grammar School. Also, it is well known that at many of the larger schools, such as Clifton College, Eton, Harrow, Rugby, St. Paul's, Giggleswick, and the North London Collegiate School for Girls, ample provision is made for teaching one or more branches of natural science; and not a few other examples might be quoted. But in how large a proportion of the schools throughout the country is such training neglected! And there is much cause for complaint in the fact that, in those schools in which science is taught, it is after all in most cases but a kind of "refuge for the destitute," only those who have failed on the classical side and those judged to be inferior in intellect being turned over to the so-called modern side. This is probably due to a variety of causes: to the ignorance, already referred to, of the public of the importance and value of such training, or it would be demanded of the schools; to the ignorance of even the barest elements of science of the majority of teachers in charge of schools; to the want of good science teachers and of suitable books; to the supposed expense of teaching science; and lastly, and I believe this to be the most important of all the causes which operate against the teaching of science, to the imperfection of our method of teaching; there can be little doubt, in fact, that the majority of teachers of the generally recognized subjects who have themselves no scientific knowledge see clearly enough that very little good comes of teaching science in the manner in which it is commonly taught in schools.

The great objection to the method at present in vogue appears to me to be that it is practically the same whether science is taught as a part of the general school course, or whether it is taught professionally; in other words, a lad studies chemistry, for example, at school in just the same way as at a science college, the only difference being that he does not carry his studies so far at school as at college. This, I believe, is the primary fault in our present system. In my opinion, no single branch of natural science should be selected to be taught as part of the ordinary school course, but the instruction should comprise the elements of what I have already spoken of as the science of daily life, and should include astronomy, botany, chemistry, geology, mechanics, physics, physiology, and zoology—the *olla podrida* comprehended by Huxley under physiography, but which is perhaps more happily expressed in the German word *Naturkunde*—in so far as is essential to the understanding of the ordinary operations and objects of nature, the teaching from beginning to end being of as practical a character as possible, and of such a kind as to cultivate the intelligence and develop the faculties of observing, comparing, and reasoning from observation; and the more technical the course, the better. The order in which these subjects should be introduced is matter for discussion; personally, I should prefer to begin with botany, and to introduce as soon as possible the various branches of science in no particular order but that best suited to the understanding of the various objects or phenomena to which the teaching for the time being had reference. The extent to which instruction of this kind is given must entirely depend on the class of scholars.

There are few teachers capable of giving such instruction, and fewer books of a character suited to ordinary requirements. The development of such a system will, in fact, require the earnest co-operation of a number of specialists; but apart from the difficulty of securing efficient co-operation, there is no reason why some such scheme should not be elaborated at no distant date. If action is to be taken, however, there must be no delay, or the opportunity will be lost. I trust that this meeting will be prepared to give much attention to this question, and that it may be possible to continue the discussion on other platforms, as it is fundamentally important and deserving of the most serious consideration of educationalists. No doubt it will be said that the object of introducing the teaching of science into the school course is to afford mental training of a particular character, not the inculcation of useful knowledge, and that this end can be secured by teaching well some one branch of science. Admitting that this has been the case, however, there is no reason why it should be in the future; if while developing the intellect it be possible—and it certainly is—to impart much valuable information, and if—as it certainly is—the teaching be rendered easier and more attractive because it has direct reference to the familiar objects and operations of nature. We cannot, indeed, any longer afford to grow up ignorant of all that is going on around us, and without learning to use our eyes and our reasoning powers; we cannot afford to be unacquainted with the fundamental laws of health; but we must ever remember that "knowledge of nature is the guide of practical conduct," and no effort must be spared to render our system of education an effectual preparation and truly adapted to the exigencies of practical life. The female educators appear already to have grasped the importance of such teaching, and under the guise of domestic economy much that I advocate is being taught in girls' schools; it is to be hoped that ere long something akin to the domestic economy course in girls' schools will find a place in boys' schools.

To pass now to the consideration of the mode of teaching my own special subject in science classes, such as those held under the auspices of the Science and Art Department, and in the introductory course for students in science schools and colleges generally. To deal first with the former. Inspection of the syllabus for the elementary stage, together with the study of the examination papers of the past few years, will show that the student is mainly required to have an elementary knowledge of the methods of preparing, and of the properties of, the commoner *non-metallic* elements and their chief compounds. There is thus practically no distinction to be drawn between the knowledge required of students under the Science and Art Department and of those who are making the study of chemistry the business of their lives. But surely it is not the function of the Science and Art Department to train up chemists, and I am satisfied that it is neither their desire nor their intention to do so; their object undoubtedly is to encourage the teaching of chemistry as a means of cultivating certain faculties, and in order that the fundamental laws of chemistry may be understood and their commoner applications realized. It is not difficult to understand how the system has grown up and why it is maintained; I do not believe it is because the Department consider it a satisfactory one; but they know full well that a better system is not yet developed, and that it would be unwise to legislate far in advance of the intelligence and powers of the majority of the teachers. With all deference, however, I venture to add that the programme has been drawn up too much from the point of view of the specialist, and that too little attention has been devoted to it from the point of view of the educationalist. The course I am inclined to advocate would be of a more directly useful character. There is no reason why in the beginning attention should be confined to the non-metals, especially when certain of the metals enter so largely into daily use; and provided that it involve no sacrifice of the opportunities of developing the faculties which it is our special object to cultivate by the study of chemistry, there is no reason against, but every reason for, selecting subjects of every-day importance rather than such as are altogether outside our ordinary experience, such, for example, as the oxides of nitrogen; even chlorine, except in relation to common salt, might be omitted from special study. The presumed distinction between so-called inorganic and organic chemistry should be altogether put aside and forgotten, and the elements of the chemistry of the carbon compounds introduced at a very early stage, in order that the phenomena of animal and plant life might come under consideration. To give the barest possible outline of a programme, I would include such subjects as the following in the syllabus:

The chemistry of air, of water, and of combustion; the distinction between elements and compounds; the fundamental laws which regulate the formation of compounds and the chemical action of bodies upon one another (*i. e.*, the nature of so-called chemical change); the chemical properties of the metals in ordinary use, with special reference to their uses and the action upon them of air, water, etc.; the composition of natural waters; the distinction between fats, carbohydrates, and albuminous substances in so far as is essential to the understanding of the relative values of different foods and respiration and growth in animals and plants (outlines of the chemistry of animal and plant life, in fact); the nature of the processes of fermentation, putrefaction, and decay.

The instruction in these subjects should in all cases be imparted by means of object-lessons and tutorial classes; lectures pure and simple should, as far as possible, be avoided. The students should by themselves go through a number of practical exercises on the various subjects. I would abolish the teaching of tables for the detection of simple salts, the teaching of analysis as at present conducted being, I believe, in most cases of very little if any use except as enabling teachers to earn grants.

In schools and colleges in which chemistry is taught as a science, and ostensibly with the object of training young people to be chemists, it is the almost invariable practice that the student first devotes more or less time to the preparation of the commoner gases, and then proceeds to study qualitative analysis; quantitative determinations are made only during the later period of the course. I believe that the system has two great faults: it is too mechanical, and does not sufficiently develop the faculty of reasoning from observation; and actual practice in measurement is introduced far too late in the course. It is of great importance that the meaning of the terms equivalent, atomic weight, molecular weight, should be thoroughly grasped at an early stage, but according to my experience this is very rarely the case; there is no such difficulty, however, if the beginner is taught to make a few determinations himself of equivalents, etc., as he very well may be. It is not necessary here to enter into a more detailed criticism, but I propose instead to give a brief description of a modification of the existing system, which in my hands, in the course of about four years' experience, has furnished most encouraging results, and which I venture to think is worthy of an extended trial.

Instead of merely preparing a variety of gases, the student is required to solve a number of problems experimentally: to determine, for example, the composition of air and of water; and the idea of measurement is introduced from the very beginning, as the determination is made quantitatively as well as qualitatively. Each student receives a paper of instructions—two of which are printed as an appendix to this paper—which are advisedly made as bare as possible so as to lead him to find out for himself, or inquire, how to set to work; and he is particularly directed that, having made an experiment, he is to enter in his notebook an account of what he has done and of the result, and that he is then and there to ask himself what bearing the result has upon the particular problem under consideration, and, having done so, he is to write down his conclusion. He is thus at once led to consider what each experiment teaches; in other words, to reason from observation. Apart from the mental exercise which this system affords, if the writing out of the notes be properly supervised, the literary exercise which it also affords is of no mean value.

In illustration, I may here very briefly describe the manner of working out the second problem in the course. The problem being to determine the composition of water, the student receives the instruction: 1. Pass steam over red hot iron brads, collect the escaping gas, and apply a light to it. (N. B. The gas thus produced is called hydrogen.) He is provided with a very simple apparatus, consisting of a small glass flask containing water, joined by a narrow bent glass tube to an iron tube (about 9 inches long and ½ to ¾ inch wide) in which the brads are placed, a long glass tube suitably bent for the delivery of the gas being attached to the other end of the iron tube. Plaster of Paris is used instead of corks to make the connections with the iron tube. The iron tube is supported over a burner, and heated to redness; the water in the flask is then heated to boiling, and the steam thus generated is passed over the brads; the escaping gas is collected over water in the usual manner. Having made this experiment, and observed that, on passing steam over red hot iron, the gas hydrogen is produced, the student proceeds to consider the bearing of this observation. The hydrogen must obviously be derived either from the water or from the iron, if not from both. Those who already know that iron is iron, so to speak, at once infer that the hydrogen is derived from the water; it is, however, pointed out that, even if it be known that iron is a simple substance, this observation taken alone does not prove that hydrogen is contained in water.

2. The student next learns to prepare hydrogen by the ordinary method of dissolving zinc in diluted sulphuric acid, and makes a few simple experiments whereby he becomes acquainted with the chief properties of the gas.

3. Having done this, he is instructed "to burn dry hydrogen at a glass jet underneath a cold surface and to collect and examine the product." The product is easily recognized as water, and the immediate answer to the question, "What does this observation teach?" is, that since iron is absent, taken in conjunction with Experiment 1, the production of water on burning hydrogen in air, the composition of which has already been determined, is an absolute demonstration that hydrogen is contained in water.

4. Having previously studied the combustion of copper, iron, and phosphorus in air, and having learnt that when these substances burn they enter into combination with the oxygen in air, the student is also led to infer from the observation that hydrogen burns in air, producing water, that most probably it combines with the oxygen, and that water contains oxygen besides hydrogen. It may be however, it is then pointed out, that the hydrogen, unlike the phosphorus, etc., combines with the nitrogen instead of with the oxygen, or perhaps with both. He is therefore instructed to pass oxygen over heated copper, weighing the tube before and after the operation, and subsequently to heat the "oxide of copper" in a current of hydrogen. He then observes that water is formed, the oxygen being removed from the copper; and since nitrogen is absent, it follows that water consists of hydrogen and oxygen, and of these alone.

5. By repeating this last experiment so as to ascertain the loss in weight of the copper oxide tube and the weight of water produced, the data are obtained for calculating the proportions in which hydrogen and oxygen are associated in water.

In practice the only serious difficulty met with has been to induce students to give themselves the trouble to consider what information is gained from a particular observation; to be properly inquisitive, in fact. I cannot think that this arises, as a rule, from mental incapacity. When we consider how the child is always putting questions, and that nothing is more beautifully characteristic of young children than the desire to know the why and wherefore of everything they see, I fear there can be little doubt that it is one of the main results—and it is indeed a lamentable result—of our present school system that the natural spirit of inquiry, inherent to a greater or less extent in every member of the community, should be thus stunted in its growth, instead of being carefully developed and properly directed.

Having in the manner which I have described studied air, water, the gas given off on heating common salt with sulphuric acid, and the ordinary phenomena of combustion, the student next receives a paper with directions for the comparative study of lead and silver (see Appendix). The experiments are chosen so as to afford an insight into the principles of the methods ordinarily employed in qualitative and quantitative analyses, and the student who has conscientiously performed all the exercises is in a position to specialize his studies in whatever direction may be desirable.

The system I have thus advocated undoubtedly involves far more trouble to the teacher than that ordinarily followed, but the student learns far more under it, and I assert with confidence that the training is of a far higher order, and also of a more directly useful character. I believe it to be generally applicable, and that it would be of special advantage in those cases in which only a short time can be devoted to the study of chemistry, as in evening classes and medical schools. At present the only practical teaching vouchsafed to the majority of students in our large medical schools is a short summer course, during which they are taught the use of certain analytical tables; as a mental exercise the training they receive is of doubtful value; the knowledge gained is of little use in after life, and the course certainly ought not to be dignified by being spoken of as a course of Practical Chemistry; *test-tubing* is the proper appellation. It is not a little remarkable also that even the London University Syllabus nowhere specifies that a knowledge even of the elements of quantitative analysis will be required of candidates either at the Preliminary Scientific or First M.B. examination, and this, too, when, as is well known, an analysis to be of any practical value must almost invariably be quantitative. It is little less than a disgrace to the medical profession that a subject of such vital importance as chemistry should be so neglected.

If, however, we are to make any change in our method of teaching science, if we are to teach science usefully throughout the country, two things are necessary: teachers of science must take counsel together, and the examining boards must seriously consider their position. There can be little doubt that in too many cases the examinations are suited to professional instead of to educational requirements; and that the professional examinations are often of too general a character, and do not sufficiently take into account special requirements.

APPENDIX.

PROBLEM: TO DETERMINE THE COMPOSITION OF AIR.

N.B.—Immediately after performing each experiment indicated in this and subsequent papers, write down a careful description of the manner in which the experiment has been done, of your observations and the result or results obtained, and of the bearing of your observations and the result or results obtained on the problem which you are engaged in solving. Be especially on your guard against drawing conclusions which are not justified by the result of the experiment; but, on the other hand, endeavor to extract as much information as possible from the experiment.

1. Burn a piece of *dry* phosphorus in a confined volume of air, *i. e.*, in a stout Florence flask closed by a caoutchouc stopper. Afterward withdraw the stopper under water, again insert it when water ceases to enter, and measure the amount of water sucked in. Afterward determine the capacity of the flask by filling it with water and measuring this water.

N.B.—The first part of the experiment requires care, and must be done under direction

2. Allow a stick of phosphorus lashed to a piece of stout wire to remain for some hours in contact with a known volume of air confined over water in a graduated cylinder. After noting the volume of the residual gas, introduce a burning taper or wooden splinter into it

N.B.—The residual gas is called *nitrogen*.

3. Burn a piece of dry phosphorus in a current of air in a tube loosely packed with asbestos. Weigh the tube, etc., before and after the experiment.

4. Repeat Experiment 2 with iron borings moistened with ammonium chloride solution. Preserve the residual gas.

5. Suspend a magnet from one arm of a balance; having dipped it into finely divided iron, place weights in the opposite pan, and when the balance is in equilibrium, set fire to the iron.

6. Pass a current of dry air through a moderately heated tube containing copper. Weigh the tube before and after

the experiment; also note the alteration in the appearance of the copper.

7. Strongly heat in a *dry* test tube the red substance obtained by heating mercury in contact with air. At intervals plunge a glowing splinter of wood into the tube. Afterward note the appearance of the sides of the tube. (Before performing this experiment ask for directions.)

N.B.—The gas obtained in this experiment is named *oxygen*.

8. Heat a mixture of manganese dioxide and potassium chlorate in a dry test tube, and at intervals plunge a glowing splinter into the tube. This experiment is to acquaint you with an easy method of preparing oxygen in quantity.

9. Prepare oxygen as in Experiment 8, and add it to the nitrogen from Experiment 4 in sufficient quantity to make up the bulk to that of the air taken for the latter experiment. Test the mixture with a burning taper or splinter.

10. Dissolve copper in nitric acid and collect the escaping gas (nitric oxide); add some of it to oxygen and some of it to air.

11. Fill a large flask provided with a well-fitting caoutchouc stopper and delivery tube with ordinary tap water and gradually heat the water to the boiling-point; collect the gas which is given off in a small cylinder and add nitric oxide to it. Also collect a sufficient quantity in a narrow graduated cylinder and treat it as in Experiment 2.

COMPARATIVE STUDY OF SILVER AND LEAD.

SILVER.—*Symbol*, AG. (*Argentum*). *Atomic weight*, 107·67. *Specific heat*, 0·05701.

LEAD.—*Symbol*, PB. (*Plumbum*). *Atomic weight*, 206·47. *Specific heat*, 0·03140.

1. Determine the relative density of lead and silver at a known temperature by weighing in air and in water.

2. Separately heat known weights of lead and silver for some time in the air, allow to cool, and weigh.

3. Separately convert known weights of lead and silver into nitrates, and weigh the latter. From the data thus obtained calculate the *equivalents* of lead and silver.

4. Convert the known weights of nitrates thus obtained into chlorides, and weigh the latter.

5. Compare the action on lead and silver of chlorhydric acid; of dilute and concentrated sulphuric acid, using the acid both cold and hot; and of cold and hot nitric acid.

6. Using solutions of the nitrates, compare their behavior with chlorhydric and sulphuric acids, hydrogen sulphide, potassium iodide, and potassium chromate. Ascertain the behavior of the precipitate formed by chlorhydric acid when boiled with water, and when treated with ammonia solution.

7. Compare the behavior of lead and silver compounds on charcoal before the blowpipe.

8. Tabulate the results of your experiments with lead and silver in parallel columns.

9. Ascertain whether the substances given you contain lead or silver.

10. Determine silver in an alloy of lead and silver by cupellation.

11. Study the method of determining silver volumetrically by means of a *standard solution* of ammonium thiocyanate. Determine the percentage of silver in English silver coinage.

12. Determine silver as chloride by precipitation.

13. Dissolve a known weight of lead in nitric acid, precipitate it as sulphate, collect and weigh the latter.

14. What are the chief ores of lead and silver? How are lead and silver extracted from their ores? How is silver separated from lead? How is it separated from burnt Spanish pyrites? What are the chief properties and uses of lead and of silver? State the composition of the chief alloys of lead and silver.

THE CASTALIA, HOSPITAL SHIP.

THE Metropolitan Asylums Board having acquired the twin-steamer Castalia, have converted it into a small-pox hospital. The arrangement of the pavilions on the upper deck is on rather a novel principle, being in "echelon;" by this means the greatest amount of light is secured all round the pavilions, besides furnishing free air passages for the purposes of ventilation.

Accommodation is provided for two hundred patients, being more than can be accommodated in all the other small-pox hospitals in London put together. Taking a warning from the evil results accruing from the defective ventilation of most hospitals, the Board wisely determined to pay special attention to the ventilation of the Castalia; and to assist them in their endeavors they adopted the prudent course of calling in to their aid the highest authorities on the subject that could be secured, Professor De Chaumont being the principal adviser.

After careful consideration and inquiry, it was decided by the Board to adopt Messrs. Robert Boyle and Sons' system of ventilation as being the best and most suitable for the purpose, and the Local Government Board having approved of and sanctioned its adoption, Messrs. Boyle received instructions to proceed with the work. This is one of the largest and most important ventilating contracts that this firm has yet undertaken; and from the peculiar nature of the application, it is also considered to be one of the most instructive examples of ventilation yet effected. For the extraction of the vitiated air there are provided twenty of the self-acting air-pump ventilators, each 6 ft. diameter, connected with the wards, as shown on accompanying diagram, by means of iron shafts measuring from 30 in. to 4 ft. diameter. There are also sixteen air-pump ventilators, 8 ft. diameter, connected with the waterclosets, lavatories, bathrooms, etc.

Fresh air is admitted all round the wards by means of openings cut through the walls at the floor level. The air passes in through these openings, and over hot-water pipes which are inclosed in a false skirting made of iron, perforated at the top to permit of the air being equally and imperceptibly filtered in and diffused throughout the wards. The supply of air is regulated by valves or shutters worked by means of screws. This arrangement is that of Mr. Adam Miller, engineer to the board. After an extended series of experiments to test the air-pump ventilators under all states of the weather, when there was a good wind blowing and when there was no wind at all, it was found that the ventilators were extracting at the rate of five million cubic feet of air per hour, the air in the wards being entirely changed once in every five minutes, while there was not the slightest disagreeable draught experienced. During the whole of the tests not the slightest down-draught was found in the ventilators. There were several anemometers used, placed in the shafts of the ventilators, readings being taken every two hours. Anemometers were also fixed outside to register the velocity of the wind. Messrs. Boyle were not present at any of these tests except the first, they (the tests) being carried out by the engineers and others appointed by the Asylums Board. Dr. Bridges, Her Majesty's Chief Inspector of Hospitals, after carefully testing the system, expressed his high approval of its action, informing Messrs. Boyle that even when he tested it in a calm he found considerable updraught in the shafts, and at no time any down draughts.

Sir Charles Dilke, and other members of the Royal Commission on the Dwellings of the Poor, accompanied by a large and distinguished party of gentlemen, visited the Castalia for the purpose of examining its arrangements, and expressed themselves highly satisfied with all they saw.

Messrs. Boyle applied their system to the Castalia under a guarantee, and the Asylums Board were so satisfied that all the stipulated requirements had been fulfilled and the system a success, that the account was paid immediately after the conclusion of the experiments. The system is also applied to the ambulance and transport steamers Red Cross, Endymion, and Albert Victor.

The value of really practical tests of this character, uncontrolled by inventors themselves, is very great, and not to be compared with experiments which are instituted from time to time by private individuals and members of sanitary associations. There is, no doubt, only one correct and really reliable way of proving the efficiency of any ventilating arrangements, and that is by the test of actual and extended practical experience. Lecture-room experiments may be all very well in theory, and show certain results; but in *actual practice* the results are often found to be different, and not seldom misleading.—*The Building News.*

A NEW METHOD OF HEATING IN THE REGENERATIVE GAS FURNACE.

DURING the present age, which may be called that of Electricity, the sister science of Heat is not receiving so much attention at the hands of the natural philosopher as it did formerly. But still there remain some scientific men who are giving a life-long attention to it—MM. Hirn and Berthelot in France, Herren Clausius, Helmholtz, and Frederick Siemens in Germany, Mr. Joule and Sir William Thomson in this country. During the late Sir William Siemens' lifetime, the one brother worked here in the science of Heat, the other in Germany, and the work of both was applied everywhere; now Mr. Frederick Siemens works alone, and, from the recent evidence of that work, it promises to play an important part in the economical application of fuel. Mr. F. Siemens has recently had an opportunity given him of bringing his views forward in this country, having read a paper at the Chester meeting of the Iron and Steel Institute on a new method of heating in the regenerative gas furnace, in which he treated the practical side of the question, while in the discussion of the same paper he gave his views on the theory of the subject. Mr. F. Siemens' investigations have led him to the conclusion that combustion can only be perfect, and be maintained perfect, if the space in which it takes place is sufficiently large to allow the gases to combine out of contact with solid materials. Having proved by actual experiment that solid substances interfere with the formation of flame, and that flame injures solid substances with which it comes in contact, he brings forward an hypothesis to account for the phenomena. According to the electrical hypothesis, which Mr. Siemens prefers, flame is the result of an infinite number of exceedingly minute electrical flashes, the flashes being due to the exceedingly swift motion of gaseous particles, and a solid body which opposes itself to these flashes is cut by them, while, the motion being more or less arrested by the solid body, the flame is damped.

Another important deduction from these investigations is that combustion should be considered in two stages or periods, which may be respectively called active and neutral. In the first the purely chemical combination of the gases takes place, during which, as soon as the temperature of ignition has been reached, the whole of the heat of the highest possible intensity is produced, of which a large portion is given off by radiation; while in the second, the temperature having fallen in the proportion of the heat given off by radiation, the remainder of the heat, which is no longer of an active character, is best transmitted by conduction. For the purpose of utilizing this portion of the heat, as well as for raising the temperature of the gas and air before combustion, the regenerators are requisite, which form an essential feature of all furnaces worked at an intense heat on the Siemens principle, care being taken to design the furnace so that the gases shall have combined perfectly before the products of combustion are allowed to pass away.

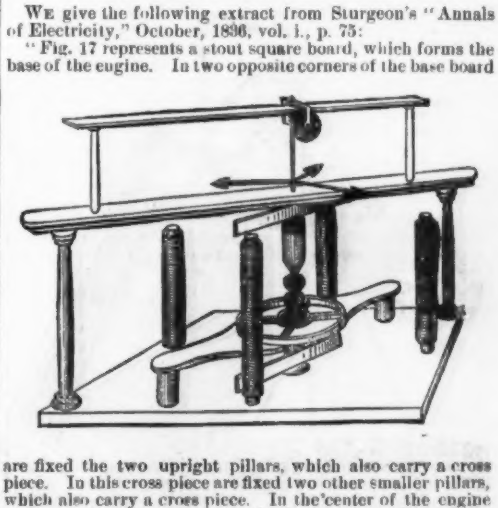
Mr. Siemens in applying his investigations to practice insists that flame must not be allowed to impinge upon bodies to be heated, but must simply heat the bodies by radiation; and furnaces must be so constructed as to allow the flame to develop out of contact, not only with the substance on its bed, but with the walls and roof of the furnace itself; it thus follows that large furnaces must replace small ones, and to meet the objection that the loss of heat into the atmosphere must increase in the proportion of the area of the furnace, Mr. Siemens explains that the heat developed in the furnace increases in a much larger ratio than its increase in area, because flame radiates in every direction from every portion of its entire volume, while a solid substance radiates from its external surface only. The details of construction of metallurgical and glass furnaces and of steam-boilers are given in the paper in question, and need not be considered here; the main point is that furnaces heated on the radiation principle have been proved, both in Dresden and at Landore, to have been economical of fuel, while the saving in the materials treated, from reduced oxidation and in the construction of the furnace, has been found to be very great.

There is another point of view of this important question which is daily demanding and commanding more attention, and that is the abatement of the smoke nuisance. As is well known, smoke is but incomplete combustion, and the only way to get rid of it is not to produce it. Mr. Siemens insists that this can only be effected by not permitting flame to touch any substance whatever so long as it exists in the active condition; for, just as carbon is precipitated upon a glass rod put into an ordinary gas flame, so is it with any flame, whatever its temperature; but the greater the difference of temperature between the flame and the body brought into contact with it, the greater will be the amount of smoke produced. Mr. Siemens tells how in Dresden he succeeded in extending his works, without the production of smoke, by the application of the system of heating he recommends, and trusts that here also not only may smoke be abated, but that the public may also derive benefit by manufacturers being able to supply goods at cheaper rates, owing to being able to economize their fuel and the material heated within the furnaces as well as that of which the furnaces are constructed.—*Nature.*

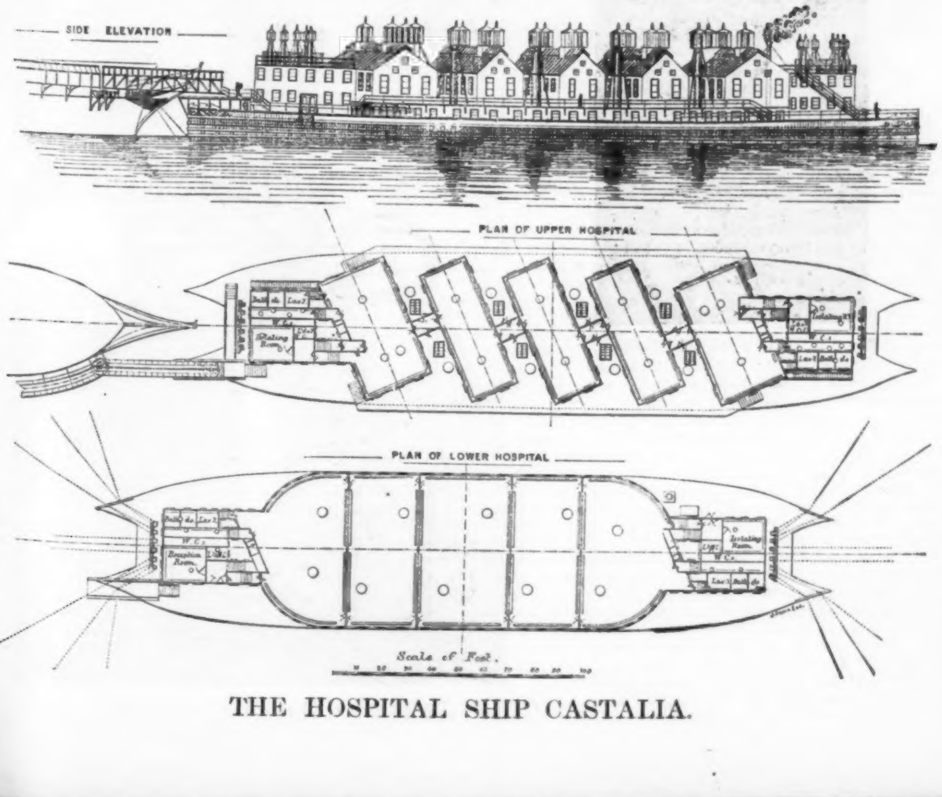
AN EARLY ELECTRO-MAGNETIC ENGINE.

WE give the following extract from Sturgeon's "Annals of Electricity," October, 1836, vol. i., p. 75:

"Fig. 17 represents a stout square board, which forms the base of the engine. In two opposite corners of the base board



are fixed the two upright pillars, which also carry a cross piece. In this cross piece are fixed two other smaller pillars, which also carry a cross piece. In the center of the engine is a vertical shaft, which turns freely in two metallic collars, one of which is in the center of the base board, and the other in the center of the cross piece. About half way up the shaft are two circular channels, one above the other, as seen in the figure. Through the center of these channels, and at right angles to their planes, the shaft passes, and is fixed to them. Lower down, the shaft passes through the center of an opening in the cross piece, also supported by two short pillars. On this cross piece, and concentric with the shaft, are fixed four quadrantal metallic plates, separated from each other by narrow radial openings. Near the top of the shaft, and at right angles to it, is fixed a compound bar magnet



THE HOSPITAL SHIP CASTALIA.

each magnet of which is about 18 inches long, 1 inch broad, and half an inch thick. Near to the bottom of the shaft is fixed another similar compound magnet, with its poles in the opposite direction to the former. In a circle concentric with the shaft, and at an equal distance from each other, are fixed in the base board the lower extremities of four cylindrical bars of soft iron, each of which is inclosed by six coils of copper wire. The coils round each cylinder are separated from each other by intervening cases of oil silk. Each set of extremities of these copper wires is soldered to one stout copper wire; hence the extremities of the twenty-four coils terminate in eight of these latter wires, four of which proceed from the lower extremities of the coils, and are soldered to the four quadrantal metallic plates, one to each. The other four stout wires proceed from the upper parts of the coils, and terminate by proper connections in the circular channels, which are partly filled with mercury. Through the sides of the channels pass four metallic stems, two through each, their inner extremities being in contact with the mercury in their respective channels. The stems of each pair are placed at 90 deg. from each other, and the whole at right angles to the shaft. The right angle which the upper pair forms is on the opposite side of the shaft to that formed by the lower pair. From each stem hangs a metallic wire, reaching obliquely to its respective quadrantal plate on the cross piece, *d d*, which maintains a connection between these plates and the mercury in the circular channels, transferring the electric current from one plate to another, and consequently from one coil to another, in their progress of revolution. To prevent the figure being distorted, none of these connecting wires are drawn.

"The engine is put in motion by the application of two cylindrical voltaic batteries of a single pair each, the metals being placed in two porcelain jars, each of which holds about three pints. These batteries are connected with the conductors of the engine at their terminal cups—one battery at each end of the lowest cross piece. The connections being properly made, the iron cylinders become magnetic in succession, and by the joint attractive and repulsive forces of the permanent magnets, and the temporary magnets, the former, with the shaft and appendages, are pulled and driven round, the action being carried on in the following manner:

"Imagine that the pole, N^1, of the permanent magnet is placed directly between the poles, *s* and *n*, of the temporary magnets; it will by this means be attracted by the former, and at the same time repelled by the latter. Hence it will be urged by both these forces toward the pole, *s*. If now the contrivance be such that the voltaic connections be broken just before the pole, N^1, arrives at *s*, the extremity, *s*, of the iron bar will become neutral; but the momentum of the machine will carry the pole, N^1, to beyond this neutral point. Now conceive that the pendent wires have been carried from their last quadrantal plates to the next in succession. The currents by this means have been reversed in all the coils, and a corresponding inversion of polarity has taken place in the vertical iron bars; hence when the pole, N^1, has just passed the first bar, and while still in motion by its acquired momentum, it will again be urged on by two other forces, in a similar manner as by the two first. For the extremity, having changed its polarity, it will now repel the pole, N^1, and drive it onward, while at the same time it will be attracted by the next bar in succession. And in consequence of similar changes of polarity taking place in all the four bars, the pole, N^1, is kept continually revolving. All that has been said respecting the pole, N^1, applies equally to the opposite pole, S^1, of the same magnet. So that by this means the magnet and its appendages are continually urged on by four forces—two attractions and two repulsions; and by considering that the lower magnet, N S, is by the contrivance also urged on at the same time, and in a similar manner, by four other like forces, it will easily be understood that the two magnets, with the shaft to which they are attached, are kept in motion by eight forces, four of which are attractive and four repulsive. Such is the contrivance for keeping the machine in motion.

"To the upper end of the shaft is attached a vertical spindle, carrying an endless screw near its upper extremity, and revolving as the shaft revolves, in a collar in the upper cross piece. Near to the lower end of this spindle is a fly with three arms, equidistant from each other, and each terminating with a heavy brass crescent. It was originally the fly of a roasting jack. The endless screw works in the teeth of a brass wheel, also a part of the old jack. The arbor of this wheel runs in a frame attached at right angles to the upper cross piece.

"This engine was constructed in the autumn of 1832, and was exhibited for the first time in London, on March 21, 1833, in a lecture on electro-magnetism, which I delivered at the Western Literary and Scientific Institution. And notwithstanding its then rude appearance, the Committee were so highly pleased with its structure and performance that they expressed a wish to have it brought forward again, and hear it explained, as soon as there was another opportunity. I was consequently honored with an engagement to continue and extend my course of lectures in the following June;

FIG. 1.—TROUVE'S INDUSTRIAL UNIVERSAL ELECTRIC LAMP IN OPERATION.

FIG. 5.—TROUVE'S UNIVERSAL INDUSTRIAL LAMP WITH THE LIGHT AT THE SIDE.

FIG. 2.—TROUVE'S INDUSTRIAL UNIVERSAL ELECTRIC LAMP NOT IN OPERATION.

FIG. 3.—TROUVE'S UNIVERSAL HOUSEHOLD ELECTRIC LAMP, NOT IN OPERATION, SHOWING THE FUNCTION OF THE PROTECTIVE PARACHUTE.

FIG. 6.—TROUVE'S UNIVERSAL ELECTRIC LAMP AS USED ON CARRIAGES.

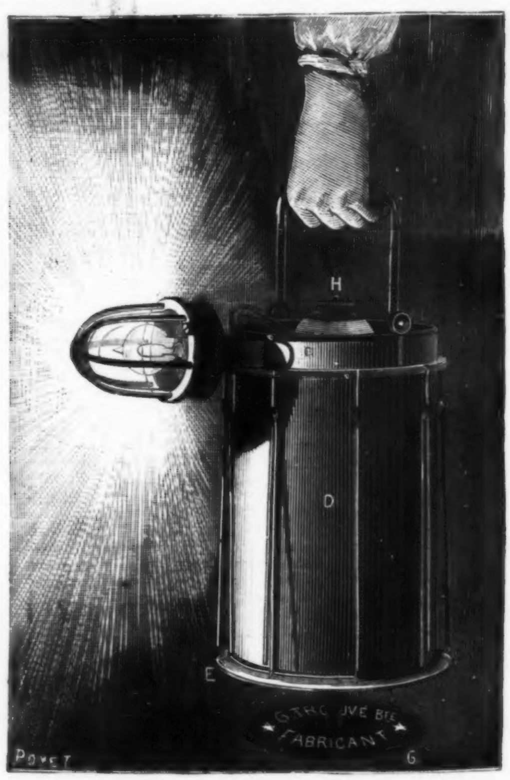


FIG. 4.—TROUVE'S UNIVERSAL HOUSEHOLD ELECTRIC LAMP IN OPERATION.

and in those lectures my engine again worked well, and excited a great deal of curiosity among the members of the Institution; and I believe was so fortunate as to give general satisfaction. Since that time I have had attached to it contrivances for drawing water, wagons, and carriages on a railway, for sawing wood, pumping water, etc., upon about the same scale as we see pieces of machinery put into motion by the large models of steam engines. But as I saw several parts in which I thought it might be improved, it has long since been laid by, and another one is now building. The old one, however, is still in existence."

From Sturgeon's "Annals of Electricity," April, 1837, vol. i., p. 250:

"In the first number of these 'Annals,' I have described an electro-magnetic engine, by means of which pieces of machinery are put in motion. I have now to announce that I succeeded in propelling a boat, and also a locomotive car riage, by the power of electro-magnetism. The particulars of their construction will be communicated as soon as their present rude state is sufficiently corrected for their appearance in public. W. S."

Vols. ii. and iii. of the "Annals" have been searched, but no further notice appears of the electro-magnetic locomotive.

TROUVE'S PORTABLE ELECTRIC LAMPS.

THE accompanying engravings represent a new style of portable electric lamp recently presented to the Academy of Sciences by Mr. G. Trouve.

Mr. Trouve has devised two well characterized types of this apparatus, one of them designed for all those industrial uses in which security is the first consideration, and the other for domestic lighting, and as a substitute for kerosene and other lamps, which are so dangerous and so inconvenient to handle.

FIGS. 7 AND 8.—UNIVERSAL HOUSEHOLD ELECTRIC LAMP WITH THE LIGHT ON TOP.

FIG. 9.—TROUVE'S UNIVERSAL ELECTRIC LAMP AS USED BY GAS LAMP LIGHTERS.

The first type, called the industrial one, is arranged in such a way as to become lighted as soon as the person who uses it (fireman, gasman, miner, etc.) hooks it to his belt so as to have his hands free. The lamp becomes extinguished as soon as it is hooked by its handle or held by the latter while being carried.

The lamp of the second type, which is principally designed for domestic purposes, becomes lighted automatically as soon as it is grasped by the handle, and goes out of itself whenever it is placed upon a table or other support. It is in such a position that we figure it herewith.

The general arrangement of the system is the same in both cases. The apparatus consists of a partitioned vessel, D, forming the receptacle of a Trouve bichromate of potash pile like the one presented to the Academy March 19, 1883. The cover of the vessel carries the pile elements, and the incandescent lamp is inclosed in a double envelope of crystal glass protected by a metallic cage. In the domestic type the lamp is sometimes fixed to the side of the pile vessel, which for this purpose is provided with a metallic ring, C. The cover that carries the elements is capable of entering the vessel that contains the exciting liquid, and it is through this motion that the lighting, regulation, and extinction of the lamp are effected.

In the second type of apparatus (see figure) the handle, F, is not fixed to the cover, but to the receptacle, and it follows that when the apparatus is carried thereby the cover is capable of freely descending so as to immerse the elements into the liquid and light the lamp. The cover is connected by a central rod to a disk beneath, which comes into contact with whatever support the lamp is placed upon. In this way, as soon as one has no longer any need of the apparatus, and places it upon any surface whatever, the pile elements rise out of the liquid and the lamp is extinguished.

The regulation of the apparatus is effected by means of a nut, H, and of an elongated screw formed upon the central rod, which permits of the position of the cover being varied upon the latter. To this domestic model Mr. Trouve has added a sort of parachute formed of ribs analogous to those of an umbrella, and which prevent the vessel from overturning when a shock causes it to tilt. This happy arrangement is shown in our figure.

These lamps are capable of furnishing a maximum luminous intensity of from 4 to 5 candles for three hours, or of 1 candle for 15; but the apparatus are constructed of different sizes according to the application that is to be made of them, so that the duration and intensity of the light may be increased at will. The apparatus are very light, and are as portable as an oil lamp, and we are persuaded that they will render a great service in the industries, as well as to all amateurs of electricity.—*La Nature.*

THE EFFECT OF PUNCHING ON STEEL.

SOME experiments have been conducted at the Pontiloff Works, St. Petersburg, by Mr. Beck-Gerhard, to determine the effect of punching upon mild steel. These experiments confirmed the already known results—that cold punching perceptibly weakens and reduces the elongation of steel, but that annealing or punching hot has no ill effect upon the material. Annealing also was shown to increase the tenacity of the punched specimen; and it was again proved that reaming removes in a great measure the evil effects of cold punching. When cold-punched soft steel was bent, it was found that the samples would not crack if the punch side of the hole was on the convex side of the bend; but the specimen invariably broke if bent in the opposite way—that is, with the die side convex. It was the same with all cast metal, hard or soft; while puddled or scrap iron could be bent either way without cracking. It is commonly supposed that the deterioration of cast steel by punching is due to the formation (on the die side) of a ring of minute incipient cracks round the punched hole. In order to prove this theory, a large number of specimens were prepared, including steel of different kinds and degrees of hardness. The edges of these pieces were planed, and the surfaces polished; but not a trace of cracking could be detected under the microscope. Although the search for cracks was fruitless, certain markings were observed on the polished surfaces round the holes. These were sheaves or bunches of lines, commencing tangentially with the holes, and curving in opposite directions, intersecting each other with some approach to regularity. Neither in drilled steel nor in punched iron plates did these markings appear; but they were most marked in the softest steel. Sometimes the markings were in relief, and in other specimens they were sunk below the surface. In order to determine how far these rays extend round a cold-punched hole, a plate 10 inches square and ⅝ inch thick was polished on both sides, and a 1 inch hole was then punched out of the center. The curved rays appeared on both sides, but particularly on the die side. When washed with aqua regia, the markings disappeared; but the surface became streaked with elongated bubbles and hair-lines arranged in the direction of the last rolling. The sample was then cut into eight test pieces, four on each side of the central hole, and submitted to tensile strains. The result showed an average ultimate resistance of 27 tons per square inch, with 20 per cent. elongation. All the fractures originated at one of the elongated bubbles; and the polished surface developed tangible ridges and indentations. On reassembling the pieces in their original shape as a 10-inch square, it was at once seen that these ridges formed together a system of curved rays round the central hole, precisely analogous to an extension of the rays at first noticed. Consequently it appeared that the effect of punching the 1 inch hole extended all over the 10 inch plate.

THE LIGHT OF FIRE-FLIES.

THE light emitted by luminous insects has often been the subject of observation and experiment. Recently MM. Aubert and Dubois have obtained some highly interesting results in this direction with a pyrophorus which arrived in a living state at Havre in a cargo of wood.

The author first submitted the light of the insect to a spectroscopic examination.

The spectroscope used was an ordinary one with a flint-glass prism of high refractive power and with a micrometer. The insect was fixed opposite the slit, which was illuminated by one of the luminous organs of the prothorax. It is, of course, well known to many of our readers that the pyrophori have three light-organs; one on the ventral side and the two others on the upper part of the prothorax. The latter, which are always visible, have been used in the experiments in question. The light which they throw off takes a divergent direction to each side of the animal, so that one and the same point cannot be simultaneously illuminated by both organs. Only one of them was, therefore, utilized. The surface to be illuminated was placed perpendicularly to the principal direction of the rays, which make an angle of about 45° with the plane of symmetry of the insect.

The spectrum of the light is very beautiful, but continuous, having neither dark nor brilliant rays.

The spectrum occupied about 75 divisions of the micrometer, extending on the red side up to the middle of the interval which separates the rays A and B in the solar spectrum. On the blue side it reaches a little beyond the ray F.

When the intensity of the light varies, its composition changes also in a remarkable manner. When the brightness decreases the red and the range disappear completely, and the spectrum consists merely of the green with a little yellow and blue. The green rays remain longest. The reverse takes place when the insect begins to emit light. The green appears first; then the spectrum extends a little on the blue side and considerably toward the red. The least refrangible rays are, therefore, the last to be emitted. No other source of light is known to behave in a similar manner.

The only case at all similar is that of strontium sulphide, rendered phosphorescent by light and by an increasing temperature. As the temperature rises the less refrangible rays appear in the spectrum, but, at the same time, according to E. Becquerel, the more refrangible rays disappear.

On examining the luminous organs with a little attention, it is found that when the light begins to appear the central and interior portion alone is luminous. It is only when the light becomes very brilliant that it reaches the peripheric stratum in which Robin and Laboulbene have proved the presence of a number of fine oily drops. These savants think that the peripheric stratum does not produce the light, and merely reflects that produced by the central portion of the organ. However this may be, it is curious to remark that the red rays do not appear until this peripheric layer becomes luminous.

The authors have next examined the photo-chemical, or, as the common expression is, the photographic power of the light. Although the spectrum extends but little toward the violet, they tried its action upon plates rendered sensitive with the gelatino-bromide of silver. After some fruitless attempts they arrived at satisfactory results. A bit of lace-work of blackened paper was placed before the sensitive place, which was then exposed to the light of one of the luminous organs placed distinctly above the middle of the design. The other organ sent its rays almost parallel to the plate, which it illuminated a little on one side. The insect was placed at the distance of 0·02 meter from the plate.

By reason of this proximity the illuminated field was of small extent, and scarcely went beyond the borders of the design, save on the side illuminated by the second organ. In order to obtain a decisive result the plate was exposed for an hour, but the action was so intense that a much shorter exposure would evidently have been sufficient. Five minutes were afterward found sufficient, and the authors think that they could have obtained results in a still shorter time if the death of the specimen had not put an end to the experiments.

The photographs show that the light of the pyrophorus has a very intense chemical action, especially if we consider that these organs, though brilliant, emit but a very small quantity of light, as was proved by photometric experiments.

The light of the pyrophorus renders calcium sulphide phosphorescent after five minutes' exposure. The phosphorescence is faint, but distinct, and lasts for some time.

On exposure to this light eosine and uranium nitrate become distinctly fluorescent.

No result was obtained with quinine sulphate or an ethereal solution of chlorophyl.

The authors conducted their researches in the Laboratory of Maritime Physiology at Havre, a genuine aquarium; and their results have been laid before the Academy of Sciences. —*Jour. of Science.*

GALL MITES.

(PHYTOPTIDÆ.)

THE Acari, or mites, are a very numerous and ubiquitous family. They may be found on our trees and plants, our domestic animals, in our food, and not unfrequently on our own bodies even. The red spiders and gall mites, etc., attack our plants, etc.; ticks and louse mites, our animals and birds; and cheese mites and their near allies, our food; harves bugs, itch mites, and some others, our bodies. The gall mites are a division of this family which live on trees and plants. They cause an unusual growth of the tissues of the leaves and buds which they attack, which in many cases form a complete covering or gall over them. These mites are very small and are hardly visible to the naked eye, yet they are able to make their presence known in a very apparent manner. Most persons are familiar with the bunches of twigs on birch trees, commonly known as witches' brooms, which may at first sight be taken for birds' nests, but which are really the work of colonies of a little mite belonging to the genus Phytoptus. The leaves of the common maple may frequently be found studded with little red roundish galls, like small coral beads, or the leaves of the lime with long pointed excrescences commonly called nail

galls (Fig. 8). These are also caused by mites belonging to the same genus. These mites are very sluggish in their movements, and do not spread rapidly, being often found on one particular tree, while others of the same kind and close to it are not attacked. They do, however, pass from one tree or plant to another in course of time, probably being transported by the wind or birds. They have no means of flying, and, unlike most mites, which have four pairs of legs, they have only two, so that without some accidental assistance it would be almost impossible for them to travel from one tree to another. The life and history of these little creatures are by no means properly understood. Some persons are of opinion that these four legged mites are only immature specimens or other kinds; others believe they are fully developed. I am of this latter opinion. I have examined numbers from the buds of the common hazel, and have never seen any showing signs of any departure from

1, Birch buds attacked by mites (natural size); 2, commencement of witch's broom (natural size).

the ordinary form. Another question is, Do the mites hibernate, or do they die, having previously laid their eggs in some suitable place where they may safely hatch in the spring? As regards those which infest buds, either of these courses would be an easy matter, but it is very different with those which make galls on leaves. The leaves fall in the autumn; if the mites or their eggs fall with the leaves, it would be impossible for the old or young mites to reach the new leaves in the spring, so one must imagine that before the leaves drop the mites must leave the galls and seek the stems, or more probably the buds, to find winter quarters in or places in which to lay their eggs. A great number of our trees and plants are attacked by these little creatures, though, except in a few cases, they do not cause any appreciable injury, nut bushes, currant bushes, birch, and yew trees being attacked by species which live in buds; while those which form galls or curl the leaves attack the alder, apple, ash, birch, beech, elm, hornbeam, horse chestnut, lime, maple, mulberry, oak, pear, plum, poplar, Scotch fir, vine, walnut, white thorn, willow, clover, salvias, and strawberry plants. When a tree or plant is badly infested, no doubt it is much injured by the loss it sustains from so many of its leaves being rendered useless, or its buds abortive. It is those species which attack the buds which are most destructive.

Nut and currant bushes are sometimes seriously injured

4, section of birch bud (magnified); 5, hazel buds distorted by mites (natural size); 6 and 7, gall mites (much magnified).

by the majority of their buds being spoilt by numbers of these mites feeding on the juices of the leaflets they contain. This action of the mites seems to almost entirely arrest the growth of the leaves; they never develop properly, and increase but little in size; the bud merely swells and opens somewhat (Figs. 1 and 5). On cutting such a bud open and examining it under a microscope hundreds of the mites may be found between the leaflets. When those species which form galls attack leaves, the latter will be generally found more or less covered with little raised excrescences or galls, and though trees attacked in this manner are not so much injured as those whose buds are destroyed, they are much weakened by so many of their leaves being rendered useless. These galls are perhaps more folds or pockets in the leaves than real galls (Figs. 8, 9, 10), for they are all open at the bottom, and are probably commenced by a mite or mites feeding at a part of the under side of the leaf, which then grows more rapidly than the rest of the leaf, owing to an increased flow of sap induced by the irritation of the mites, and gradually forms a chamber round them. True galls, such as are made by the grubs of gall flies, two-winged flies, some saw-flies, and other insects, are formed in a different manner, the abnormal growth entirely surrounding the insect, and in the midst of which it lies in a cell a complete prisoner. The galls formed by gall mites are frequently lined with hairs, and the mouth is generally furnished with a tuft of hairs, and is on the lower side of the leaves. Some species attack the edges of the leaves, which then begin to curl, and thus afford them protection (Figs. 11 and 12). Quick-set hedges are sometimes for yards together attacked in this way, the edges of nearly every leaf being rolled up, giving that part of the hedge a very strange appearance. The plants attacked must be considerably injured by their leaves being treated in this manner. As the mites so thoroughly shelter themselves either in buds or leaves, it is clear no insecticide can be of any use, unless their winter quarters could be found, when it is possible it might then be made to reach them; but even then, as they are very tenacious of life, it would not be of much use. The best means I can suggest for getting rid of them is by removing the infected parts and burning them; or if thrown on the rubbish heap it will not much matter, as the mites will not be able to regain the trees. All the phytoptidæ resemble one another very closely and are very minute, being less than 1-100 of an inch in length. On account of their minute size and the difficulty, owing to their fragileness, of mounting them for examination, I have been unable to detect any difference between the species which attack the birch, hazel, and white thorn, except that the last named does not appear to have the two long curved hairs near the tail; but I have no doubt that they are different species.

These mites (Figs. 6 and 7) are cylindrical, long, and narrow. They are widest where their cephalo-thorax joins their body; their taper gradually toward the tail, where their body is somewhat curved downward, and is terminated by a bilobed sucker. The front part of the body (cephalo-thorax) is striated longitudinally, and the remainder of the body transversely; between every two of the latter striæ is a row of minute tubercles. Nearly all the Acari have four pairs of legs, but the members of this genus have only two. This

8, Lime leaf with nail galls (natural size); 9, nail galls (magnified); 10, section of nail gall (magnified); 11, white thorn leaf rolled by mites, under side (natural size); 12 section of roll (magnified); 13, transparent stout hairs from roll (magnified).

has much puzzled entomologists, and made some think that they are only immature specimens of some other species. The four legs which these creatures have are what would be the first two pairs in other mites. On either side of the body near its base is a long, stiffish hair, and near the tail are two stiff curved hairs. When the mite moves, it crawls with its legs and moves its body forward in rather a worm-like manner, clinging on with the sucker at its tail now and then. It is able, having taken a good hold with this appendage, to raise its body into an erect position; the use of the bent hairs is not very obvious. The witch's broom in the birch trees are formed by Phytoptus betulinus in the following manner: The mites attack a bud, which then grows (as in Fig. 1, and of which Fig. 4 is a magnified section); from this bud various shoots and buds grow. These are in turn attacked by the mites, and gradually the commencement of a "broom" is formed (Fig. 2). This eventually grows by the mites continually distorting the buds into the well-known tangled mass of twigs. The species which attacks the hazel buds (Phytoptus coryli) go to work much in the same manner, but the result is merely the abortion of the bud (Fig. 5). Those which form the nail gall on the lime leaves (Phytoptus tiliæ, Fig. 5) and other galls attack the leaves at various points, from which, as before mentioned, the leaf grows, forming a chamber over them (Figs. 8, 9, and 10). White thorn leaves when infested behave in a very different manner. The mites (Phytoptus oxycanthæ) congregate near the edges underneath, which cause them to curl over toward their lower sides (Figs. 11 and 12), and that part of the under side which is thus inclosed is covered with short, stout, transparent hairs (Fig. 12); among these hairs the mites may be found. The part of the leaf thus rolled up is paler in color than the rest.—*G. S. S., The Garden.*

PALMS IN SMALL POTS.

FEW plants can be kept longer in good health without shifting than palms. The great point is not to allow them to become dry during the growing time, and to feed them with liquid manure from the moment they come into a root-bound condition. Then the leaves do not turn yellow, but retain the rich, dark hue of perfect health. In a general way palms are shifted too frequently, and in many instances it would be better to keep them another year in the same pots, at the same time feeding them liberally. The great point is not to let them become stunted from want of food, but to give them weak liquid manure about twice a week from the time they start into growth.

J. CORNHILL.

SEPARATING OXYGEN GAS FROM THE ATMOSPHERE.

SOME years ago, says the *American Chemical Journal*, Sainte-Claire Deville and Troost showed that hydrogen gas is capable of passing through platinum and iron at a red heat. Recently the latter of these investigators has shown that silver acts in a similar way toward oxygen.

A tube of pure silver of 0·01 m. diameter, and with walls 0·001 m. thick, was inclosed in a somewhat larger platinum cylinder, and the whole heated in the vapor of boiling cadmium. On exhausting the silver tube with a Sprengel pump, and passing oxygen into the space around it, the gas was found to enter at a rate corresponding to 1·700 lit. per hour for each square meter of surface exposed. On passing air instead of oxygen into the outer chamber, oxygen with only a trace of nitrogen was found in the interior, but the rate of transfusion was diminished nearly one-half. By using a tube of slightly thinner walls, the gas entered much more rapidly. Instead of exhausting the tube, the author found it necessary only to pass slowly through it a stream of some other gas, such as carbon dioxide, although this lessened considerably the rate of transfusion. The oxygen was replaced by other gases, such as carbon dioxide, carbon monoxide, and nitrogen, but they passed through the walls of the tube with extreme slowness. The author states in conclusion, that this property of silver may some time be utilized to extract oxygen directly from the atmosphere. For this purpose, it would be necessary to expose a large surface by using coils of tubes with thin walls; and to use either an exhaust pump or a stream of carbon dioxide, which could be absorbed an alkali, leaving pure oxygen.

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